SCHOOL HYGIENE

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PREFACE

In this work the author has endeavored to set forth the conditions which should surround pupils at school, in order that their mental and physical health may be thoroughly protected. He holds that it is in the highest degree incumbent upon school authorities to provide the best attainable conditions, not only to protect, but also to promote the health of pupils committed to their care. The school exists for the betterment of the state of society. In its equipment and management the newest and best recommendations which are approved by science should at once find their way into adoption and use. The home may be educated to a great extent through the school. As the school, therefore, reacts closely upon the home, a knowledge of that which is hygienically best can in no other way be so quickly and thoroughly diffused. The author desires to express his thanks to Supt. Charles E. Gorton of Yonkers, N.Y., for valuable suggestions and careful reading of a large part of the work, and also to his colleague, Linnæus E. La Fétra, M.D., for suggestions and additions to the chapter on Diseases which Concern the School.

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EDITOR'S INTRODUCTION

The most grievous single obstacle in the way of the spread of sound educational principles is the popular view that the essentials of education are limited to instruction in reading, writing, and arithmetic. It might fairly be argued, and with no small force, that the possession of so much knowledge alone is a positive detriment to a human being, especially if that knowledge has been gained at the expense of physical and moral habits which in educational value far outweigh such meagre intellectual attainment. The story of the way in which this misconception has imbedded itself in the popular consciousness, together with the larger confusion of education with instruction, is a long one and need not be recounted here; it is sufficient to say that sound educational theory to-day finds no place for any mental training which overlooks the relation of mind and body and its hygienic and ethical import.

It is not too much to say that health, its provision and protection, is all-controlling in present day educational theory, although it is unfortunately far from being so in practice. The chief reason for this discrepancy between the ideal and the real is simple ignorance. Teachers and parents do not recognize that eyesight is being impaired, normal growth prevented, blood poisoned, and

the body starved, because the hours of school life are so often unhealthy and abnormal hours. School buildings are constantly erected with a view to exterior effect alone, and an adequate system of ventilation and a proper site are pronounced too costly. Years of useful, happy life for scores of human beings count as nothing in comparison with the opportunity for immediate saving of a few hundred dollars. School boards and school architects would not, of course, consciously pass any such judgment; it is lack of knowledge and lack of appreciation of the facts which make it possible.

Just so it is utterly fallacious to urge the compulsory attendance of children at school, regardless of the school conditions. It is not true that a child is always and everywhere better off in any school than running at large in any village or city. If the class-room is already overcrowded, if there are already far too many pupils assigned to a teacher, then every additional pupil who is brought in injures those who are already there and receives injury himself. For this reason our compulsory attendance laws need to be enforced with great discretion, so long as present conditions exist, lest they defeat their own purpose.

In the present volume the author brings the essential facts of school hygiene or school health within the reach of any inquiring parent or teacher. He has done a special service in examining with particular care the hygienic aspects of instruction in handwriting, and in passing in review the general conditions favorable to mental work.

We have come to realize that the connection between physical health and the power of voluntary control, and consequently of conduct, is very close. Preservation of health is therefore an aid to character building, and the subject of school health makes a double appeal to us.

NICHOLAS MURRAY BUTLER

COLUMBIA UNIVERSITY, NEW YORK
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SCHOOL HYGIENE

CHAPTER I

The Schoolroom

The schoolroom the unit in planning a school building — In this book we shall first enter upon a consideration of the schoolroom from the point of view of hygienic requirements, in order to direct attention more strongly to its fundamental requisites. We hold that the schoolroom should be the unit first to be considered in planning a school building, and that the building should be a number of schoolrooms, properly disposed, and not a whole cut up into schoolrooms, whose size and arrangement are dependent upon the size and shape of the building. If the hygienic requirements of a schoolroom are first clearly and fully understood, and then firmly held in mind, the building is much more likely to be considered as the grouping of the number of schoolrooms required, with halls and other auxiliaries, and is, therefore, much more likely to be so planned as to give each unit, or schoolroom, what the laws of health demand for the pupils who are to occupy it.

The general form of the schoolroom should be that of an oblong, with the aisles between the desks running the long way of the room. One advantage of this shape is the better lighting of the schoolroom which it affords. Another advantage is that the pupils are able to see more clearly and with less effort, whatever apparatus the teacher finds it necessary to present, be it chart, globe, map, physical apparatus, or exercises written on the blackboard behind the teacher's desk. Under such conditions, these objects receive the least possible foreshortening to pupils who happen to be sitting on the teacher's extreme right or left.

The size of the schoolroom is dependent upon several factors. Certain conclusions with reference to its size have at last been reached, and these conclusions have been so thoroughly tested and sanctioned by the most careful school men as to warrant their being regarded as standards. These standards are the results of investigations and repeated experiments, in which lighting, heating, ventilating, the needs of the child as to eye, and ear and other physical requirements, have been considered. They are the outcome of the special knowledge and recommendations of physicians, architects, and engineers, and of the practical judgment of school men, after repeated test and modification.

These standards demand, in the first place, 15 sq. ft. of floor space and 200 cu. ft. of air space for each pupil, as the least amount of floor space and air space

permissible for a schoolroom, when all the needs of health are fairly considered. In the second place, they demand that the size of the schoolroom should be 30 ft. in length, 25 ft. in width, and 13 ft. in height, to accommodate not more than 48 pupils.

It will be seen that with a schoolroom 30 ft. long, 25 ft. wide, and 13 ft. high, for 48 pupils, each pupil will have a little more than 15 sq. ft. of floor space, and a little more than 200 cu. ft. of air space. If such a room can be limited to 40 pupils, there would be $18\frac{3}{4}$ sq. ft. of floor space and $243\frac{3}{4}$ cu. ft. of air space to each pupil. Such conditions are in this case preferable to 15 sq. ft. of floor space and 200 cu. ft. of air space. But an increase of square feet of floor space per pupil which would increase the dimensions of the room in length and breadth is not permissible; for the distance light will carry, admitted at the side of the room, or at the side and back of the room, the distance pupils can see without strain upon the eye, and the distance the words of the average teacher are clearly audible, are determining factors as to the length and width of the schoolroom.

One writer on school hygiene gives 32 × 24 ft. as the length and width of a schoolroom. With a proper amount of glass surface to admit sufficient light, the room may safely be made one foot wider than this, that is, 25 ft. wide, when the ceiling is 13 ft. in height. But if the room is 32 ft. in length, and lighted from

the side and the rear, the desks of some pupils, in order to receive the greatest amount of light, must be placed too far away from the front blackboard to see without straining the eyes.

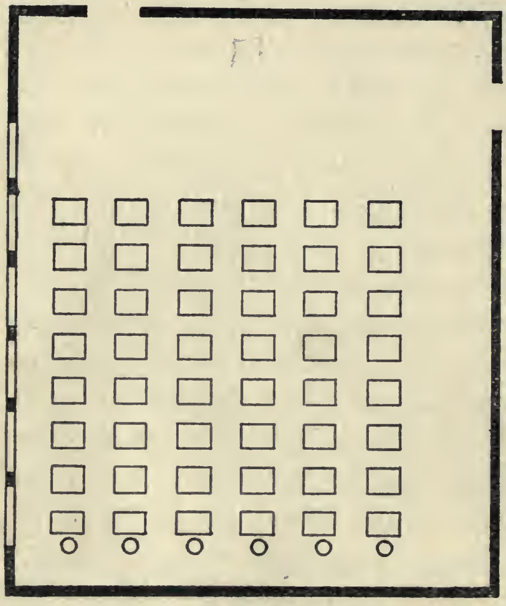


FIG. 1.

Schoolrooms for primary grades not to be smaller than for higher grades—Some writers on school buildings have recommended smaller schoolrooms for primary grades, on the ground that primary desks and chairs occupy less space than chairs and desks for higher grades. It will be seen that making the room smaller reduces the number of cubic feet of air space to each pupil. In Fig. 1 is shown a schoolroom 25 × 30 ft., seated to accommodate 48 primary pupils. By comparing Fig. 1 with Fig. 2, a room seated for 48 grammar pupils, the gain in space not required by primary seats and desks

will be seen. This additional space is especially needed in primary schoolrooms, to give opportunity to conduct different exercises and activities at the same time, a practice which has now become, through division of children into groups, an important one in primary teaching.

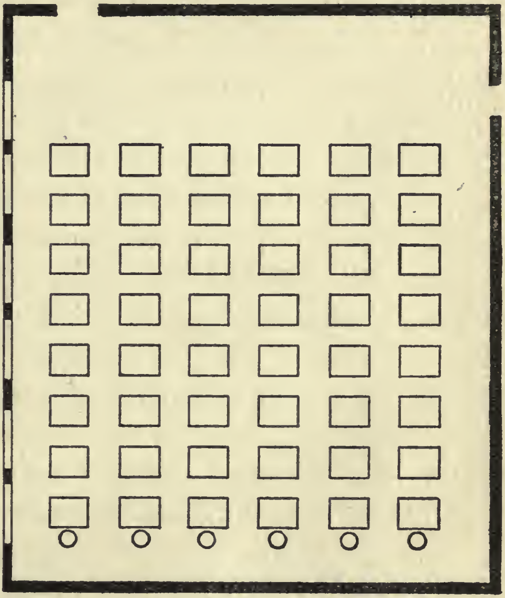


FIG. 2.

Besides, more floor space is needed in a primary room, in order that the teacher may provide for the greater motor necessities of primary pupils. Primary pupils should not spend more than one-third of the time at school in their seats. Exercises of various kinds that call into play muscular activity are most imperative at this age, not only for mental growth, but also for physical growth, as well as for relief from the fatigue which sitting at desks occasions in children.

Let those who recommend the smaller schoolroom for primary pupils consider the change which a child experiences when he begins school life. He enters an environment radically different from the life of varied activity and freedom from confinement which was his before school days began. Let it be also remembered that so severely does the new environment tax the child that he usually falls off in weight, his nervous system becomes affected, and certain physical functions become more or less disordered.

More air space and floor space are imperative in primary grades, because activity for the child is vital. The lack of floor space to give the child the physical activity his rapidly developing organism requires, the lack of floor space to afford him relief from the fatigue which even the most approved school desk causes, may be set down as a condition which fosters habits of defective posture that end in permanent distortion of the body. Faulty habits of sitting result from fatigue and inactivity even with hygienic desks. An abundance of space, therefore, for physical activity, making this a contributing part or an accompaniment of the mental exercises, would save many a child from falling into postures that at last become permanent and, in later years, so pronounced that all attempts to correct them prove futile.

Instead, then, of decreasing the size of primary rooms, we would keep them the size of the standard

schoolroom, 25 × 30 ft., and absolutely limit the number of pupils to 40.

A primary schoolroom, therefore, of 25 × 30 ft., for even 40 pupils, is none too large, if the teacher is to be given opportunity to provide for the healthy development of the child in its mental and physical nature.

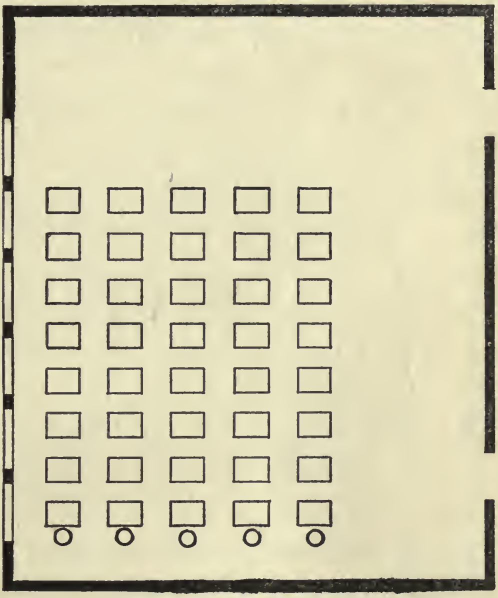


FIG. 3.

In Fig. 3 is shown the plan of a primary room seated for 40 pupils. When it is remembered that a part of the space unoccupied by the desks and desk chairs must be given up to teacher's desk, to sand table, and to number table which also serves for certain kinds of manual work, it will be seen that there is no more space than is necessary to meet the hygienic demands of the pupils for physical activity.

If it is desired to furnish more than 15 sq. ft.

of floor space to each pupil, it can be done, provided a sufficient amount of light is admitted. A higher ceiling, with the windows reaching up to it, will give more light, but the higher ceiling necessitates the climbing of longer stairways by pupils going to all floors above the first. There are, also, other objections to high ceilings which will be pointed out in the next chapter.

It may be said, however, that with 18 sq. ft. of floor space to each pupil, all class-room exercises are made easier for teacher and pupil.

Lighting of the schoolroom — The schoolroom cannot be too well lighted. Writers upon school hygiene uniformly agree that the amount of transparent glass surface admitting light should be from one-fourth to one-sixth of the floor space of the room. The amount of glass surface, therefore, in the windows of a standard schoolroom, 30 × 25 ft., would be 187.5 or 125 sq. ft., as we adopt the larger or the smaller ratio. In building schoolhouses the lower ratio is too frequently adopted. There is perhaps no other matter in school equipment so deceptive as the adequate lighting of the schoolroom. It is a very simple matter to measure exactly the ventilation of a schoolroom, or the humidity of the air at any given time. But the measurement of the degree of illumination is much more complicated and difficult. Empirical or practical judgment is of little account as to whether a room is sufficiently lighted. A room may seem well lighted, and may be

pronounced well lighted, when only the general illumination of the room is considered. When, however, tests are instituted, it will likely be found that there are desks where the lowest illumination is below the permissible minimum. On clear days, when there is an abundance of sunlight, a room with the lowest ratio of transparent glass surface conceded by writers on lighting will be strongly lighted, provided, of course, the sky as seen from the pupils' desks is not partially obstructed by buildings or trees.

But the amount of transparent glass surface required for proper illumination must not be determined by the illumination such area will give on clear and bright days. The amount of transparent glass surface must be great enough to afford sufficient illumination on rainy, overcast, and otherwise dark days. During the first week in November the illumination on a desk 5 ft. from a large window was measured early in the afternoon, with the sun shining. The window had a clear sky exposure. The illumination of the same desk was measured ten minutes later, but when the sun was obscured by heavy passing clouds. The illumination with the sun obscured was, according to the measurement, one-third of the illumination when the sun was shining. It should be stated that the window faced a west-northwest direction, and that at the time of the measurement the sun had not reached a position to shine into the room.

During the part of the year from the middle of October to the first of March, the sun is running low in the heavens, and the illumination it affords is not so great as during the part of the year when the sun is higher in the heavens. If, further, we take the time from the first of November to the middle of April, there is a large proportion of rainy and dark days. The amount of glass surface must, therefore, be great enough to admit sufficient light on cloudy days, and also on the dark days of the part of the year just mentioned.

The point to be emphasized is that in determining the amount of transparent glass surface necessary for the lighting of a schoolroom, provision for sufficient illumination on dull days is likely to be overlooked. Could all school days be clear days, with bright sunshine, a standard schoolroom with clear sky exposure would be well lighted in every part if the transparent glass surface was one-eighth of the area of floor space.

The amount of illumination for the desk in the most unfavorable part of the room should not be less than fifty candle metres. This is greater than the amount required by Cohn, which it seems to the writer is too low. Cohn's requirement is based on measurements with Weber's photometer, and the various reductions of light made necessary by the method which this instrument necessitates, lead to underestimation.

By a candle metre is meant the illumination

afforded by a standard candle at one metre's distance. If the illumination falls below fifty candle metres, the pupil's eyes are subjected to an undue strain in ordinary work at his desk.

For rooms, then, having a southern exposure and clear sky line, the amount of transparent glass surface should be one-fourth of the amount of floor space, in order to insure a sufficient illumination on dull days. It is always an easy matter to exclude light by means of shades, if in bright weather so much enters as to produce a dazzling effect. For rooms having a northern exposure, the amount of glass surface should be somewhat greater than one-fourth of the floor space.

Rooms with windows having obstructed sky line — If the expanse of sky is partially obstructed by buildings or trees, provision must be made to counteract this. Tests on the diffusion of light through windows set with prismatic, maze, and factory ribbed glass, made at the Massachusetts Institute of Technology in September, 1900, by Charles L. Norton at the suggestion of Edward Atkinson, have an important bearing on the lighting of schoolrooms. The conclusions reached are of especial value, and the application of the knowledge resulting from these experiments will solve the problem of increasing the illumination of schoolrooms, where the expanse of sky is largely cut off by the proximity of buildings.

In Fig. 4 an enlarged section of the factory ribbed glass which gave the best results is shown. The

FIG. 4.

factory ribbed glass, plane on one side, and having twenty-one ribs to the inch in true curves, concave and convex, proved to be the most effective. It is made in large sheets for glazing, and costs about the same as good double thick glass. For schoolrooms 20 to 30 ft. in width or length, as the direction may run from the windows, and with a sky angle of sixty degrees or less, the effective lighting can be increased on bright days fifty per cent, and on dark days more than fifty per cent if the upper sash is glazed with factory ribbed glass. If in addition to this the upper half of the lower sash is glazed with the ribbed glass, the increase in the illumination of the room will be much greater. The glass should be set with the ribs running horizontally, and if the sun's rays fall upon it, it should be protected by a thin white shade.

Sometimes glazing with factory ribbed glass will give more effective lighting if it is set with the ribs running vertically; as for instance, when there is a narrow vertical opening exposing a low sky line between buildings opposite the schoolroom windows, and which otherwise obstruct the expanse of sky.

The illumination of schoolrooms may also be very greatly increased by employing sashes or canopies

made up of Luxfer prisms, especially when the windows open upon narrow streets, courts, or alleys. These prisms gather direct light from the expanse of sky above the tops of buildings, and reflect and diffuse it with imperceptible loss into the schoolroom.

The Luxfer prism is simply a thick small pane of glass with raised prisms on one side, a photograph of which is shown in Fig. 5 (facing p. 101). The panes of glass are each four inches square, and the angles of the raised prisms vary in different panes, so as to gather light from any expanse of sky from forty-five degrees of exposure to the zenith, and also to refract the light gathered to any part of the room desired. The great value of these prisms lies in the fact that they may be so placed as to take the strong light from the clear expanse of sky, and by refraction and reflection throw it back into the parts of the room where light is needed.

When the angle from the zenith to the limit of sky expanse as seen from the window is known, and also the direction in which the light must be distributed in the room, proper prism panes are selected, copper strips are placed between them, and then the panes are firmly glazed by means of electricity into one large pane. This is inserted in the sash if the angle of the sky exposure will permit, or it is placed outside the window at an angle as a

canopy if the angle of sky exposure is small. Light is thereby equally distributed to all parts of the room.

Much relief for the eyes of children would be afforded by providing factory ribbed glass or Luxfer frames or canopies for the windows of all schoolrooms insufficiently lighted. And it may be remarked that the number of such schoolrooms in our cities is exceedingly large.

Mr. Edward Atkinson, in a statement prefacing the investigations referred to above, points out that the upper sash of schoolroom windows might be glazed with prisms to deflect the light to the white ceiling, from which it would be reflected to the desks. Cloth shades would then not be needed, even on the sunny side of the building, and the danger of any bright lines of light injurious to the eyes of pupils being thrown on the desk would be obviated.

Direction from which light may enter — Having considered the amount of light necessary for a schoolroom, we pass to a consideration of the direction from which the light should enter, and also the disposition of the windows of a schoolroom.

There are two directions from which all authorities are agreed the light should not enter. First, from the front of the room, as the light comes directly into the eyes of the pupils; secondly, from the right, as this causes the pupil in all exercises with pen or pencil to look at his writing or ciphering in the

shadow cast by his hand. Shadows and half shadows are always to be avoided. Persons whose sight is beginning to be impaired are first made aware of it by their inability to see to read in half shadows.

There is a unanimity of opinion that light may enter from the left. Under these conditions the pupil in writing and drawing sees his work clearly, there being no half shadow of the hand to obscure it.

There is, however, a difference of opinion as to whether light should be admitted from the rear of the room. The main points in lighting are that there shall be an abundance of light and that it shall be so distributed and diffused as to avoid half shadows, as partial shadows are very injurious to eyesight.

Some authorities recommend that windows be placed in the rear of the schoolroom. Windows admitting light from the rear of the room can be so arranged that the light coming from them will be well distributed and well diffused. Such windows, however, must not admit so much or so strong light as to overpower that coming from the left, otherwise the pupil would be working in a partial shadow. Windows in the rear of the room also often afford a means of lighting a room with diffused light, when the shades on the left side of the room are drawn to shut out the direct rays of the sun.

There is, however, one objection to placing windows in the rear of the room. The teacher's eyes are likely

to be weakened and injured by facing the light from windows so placed. There is reliable testimony to warrant the statement that the eyes of at least seventy-five per cent of teachers would be injured by facing such light. It may be added that in France windows in the wall opposite the teacher's desk are expressly forbidden.

On the other hand, it has been said that the teacher may change her place frequently, or, if provided with a swivel chair, may change her position with relation to the light.

There are some conditions under which windows may be placed on the right side in order that a schoolroom shall be sufficiently lighted. This statement may at first appear to be in contradiction of the requirement already set forth, that light should come from the left. Although light should never fall on the pupil's desk directly from the right, yet windows may be placed, if absolutely necessary to secure sufficient light, on the right side of the room, provided great care is exercised as to their size and position. In case, then, a schoolroom is insufficiently lighted and more light cannot be admitted from the left or rear, the windows placed on the right should have their sills 8 ft. above the floor, and the amount of light admitted by such windows should in no instance be strong enough to overpower the light admitted from the left. Otherwise the stronger light from the right would cast a partial

shadow of the pupil's hand on the paper, and in writing, drawing, or ciphering, this partial shadow would shade the part of the paper to which he is directing his vision. The accommodation of the eye, therefore, would be constantly taxed to adjust itself to the different degrees of illumination on the paper, and the eye would suffer injury.

The suggestion made by Javal, and seconded by Cohn, that the schoolroom be lighted from above, is to be approved theoretically, but when the suggestion is considered with reference to its practical aspects, it is not feasible in the building of school houses.

Spaces between windows — As has already been stated, bands of light in alternation with shadows are injurious to the eye. It is plain, then, that the windows should be set with the least possible space between them; for if set with a large distance between them, the light is admitted in bands, and there are deep shadows between these bands. Such alternate zones of light and shadow are injurious to the eye. The piers between windows should be as narrow as possible. Cohn recommended that the piers between the windows, instead of being rectangular, should be bevelled. Mr. Warren R. Briggs has used, in school buildings constructed by him, a cast-iron mullion between windows. By this means he has avoided ordinary piers of brickwork 18 in. wide,

and has reduced the distance between windows to but little more than that required for the window frames and weight boxes.

Height of windows — The windows should extend as near the ceiling as possible, leaving no wall space between the trim of the window and the ceiling; that is, the glass should reach to within 6 in. of the ceiling. The higher the window extends, the better is the illumination, as the light coming in at the top of the window is reflected from the ceiling, and is therefore better diffused, while a considerable amount of the light coming in at the bottom of the window is absorbed by the floor, desks, and wainscoting. Actual measurements show that the upper fourth of the window furnishes one-third of the light coming through the whole window. In a well-lighted school building recently erected at Zurich, the glass surface, by a peculiar device in construction, extends up to the ceiling.

It will be obvious, therefore, that windows arched at the top decrease the admission of light at its most valuable point, and are not to be sanctioned for a schoolroom, unless the ceiling is so high that the lower points of the arch are at least 13 ft. above the floor, the windows wide, and the requisite amount of transparent glass surface is provided.

Nor should the windows have a transom at the top. The bar separating the transom from the remaining

part of the window excludes light, and also produces a half shadow. The transom, moreover, is likely to be covered with a fixed shade, and thus light is excluded at the most valuable part of the window opening.

The sills of the window should be of such a height from the floor that the light entering the lowest part of the window will not produce reflections from the tops of the desks, or be on a level with the eyes of pupils when they are seated at their desks. If the window sills are 4 ft. from the floor, both these injurious effects of lighting will be clearly avoided. Window sills, however, may be safely made $3\frac{1}{2}$ ft. above the floor. Robson, an English authority, gives 5 ft. as the height of window sills from the floor. If window sills are 5 ft. from the floor, the amount of glass surface is considerably decreased, provided the height of ceiling is kept at 13 ft. With windows having a width of 40 in. of glass, there is a loss of 5 sq. ft. of light opening to each window. If there are six windows on the side of the room, there is a loss of 30 sq. ft. of opening — or $6\frac{2}{3}$ sq. ft. more than the opening afforded by a window under the assumed conditions; namely, $7 \times 3\frac{1}{2}$ ft. With sills 5 ft. from the floor, therefore, rooms which must be lighted from the left side only would fall considerably below the amount of transparent glass surface necessary to light them properly. But with the sills $3\frac{1}{2}$ ft. from the floor, the window may be 9 ft. in length. Making the width of glass 42 in., the window

would afford 31.5 sq. ft. of glass surface. With six windows on a side, there would be 189 sq. ft. of glass surface, or rather more than one-fourth the area of floor space.

This length of window and height of sill are advocated because of the increased transparent glass surface which they afford, such an amount being needed on dark days for adequate illumination. It will be seen that by employing opaque shades rolling from the bottom, as recommended by Marble, light may be shut out from the bottom of the window when there is sunshine or an abundance of light out of doors, and the strong light may thus be excluded from the eye level of the larger pupils — the heads of the smaller pupils when seated being below the lowest bar of the sash. On overcast and dark days, light entering at such a level for large pupils will not prove in the least objectionable.

Although the requisite amount of glass surface could be secured by making the ceiling higher than we recommend as best for health when all factors are considered, yet there is something to be said on the grounds of mental if not physical health, against adopting 5 ft. as the height of window sills. With this height few children can look out of the windows. This results in a serious deprivation, and such a condition must invest the schoolroom, to the minds of the pupils, with an air of confinement, an influence

which is extremely baneful. The child's mind, when not occupied with his tasks, at recess, and during the hours of intermission, is rested and refreshed by looking out of the window. He is interested in the outer world, no matter what it may chance to be, and it has an important contribution for him in many particulars, which must not be cut off even in the schoolroom.

The placing of windows — The windows admitting light from the left should begin as near the back corner of the room as possible. There seems to be no reason, with care in construction, why the first window may not come as near the corner as 2 ft. Numerous instances of such distance are to be found in school buildings recently erected. The windows on the left side should be placed with the least possible distance between them. If the room is lighted from the left side only, the windows, in order to give the requisite amount of transparent glass surface, will need to extend nearly to the front end of the room.

If there are windows at the back of the room, these should be as large as possible, but not so large as to admit light enough to overpower that coming in from the left and so produce half shadows. The one nearest the left corner need not be so near the corner as the side window, but the distance of this window from the corner should be increased in order to place the end windows so that light may be afforded

to the right side of the room. Figure 2, page 5, and Figure 6 show the placing of windows for two schoolrooms, one where it is possible to light only from the left, and the other lighted from the left and the rear.

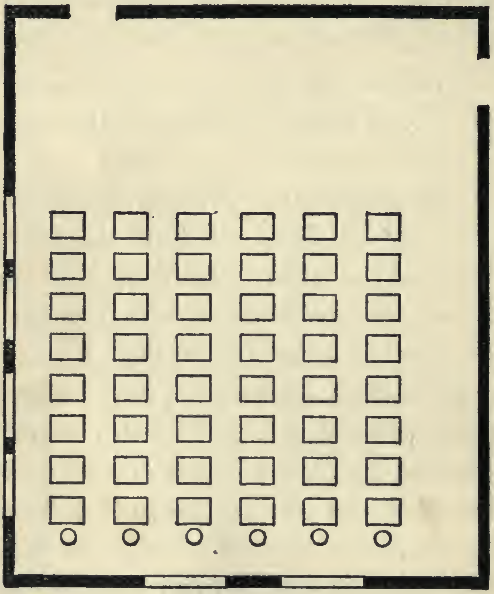


Fig. 6.

It may be remarked that it is better so far as lighting is concerned to have the fewest number of panes of glass in a window. One pane for the lower sash and one for the upper will prove best. The windows are the more easily kept clean, and none of the available window opening is obscured by the cross-bars of the sash.

Color of Walls — An important matter related to the lighting of the schoolroom is the color of the walls. In view of the stress which has been laid upon the necessity for the fullest illumination of the schoolroom possible, no color must be put upon the walls which

absorbs light to an appreciable degree. In selecting the color for schoolroom walls, it becomes a question of determining what color will, in the first place, absorb the least amount of light, and in the second place, prove least taxing to the eye. It is plain, then, that the red end of the spectrum, or, in other words, reds of all tones, are to be avoided, as these absorb too great a proportion of light. Light yellows and buffs have been recommended by some on the sole ground, it seems, that they absorb the least amount of light, and are, therefore, very favorable to illumination. In this recommendation, however, some very important factors have been overlooked. Investigations have brought out the fact that yellows produce fatigue and nervousness to a marked extent, as compared with other colors. Yellows are not restful to the eye. The quality of the sensation produced by them seems to be fatiguing.

On the other hand, the abundance of green in nature when illumination is the strongest would seem to indicate, as many hold, that green is restful to the eye.

If, further, we examine the curve of the degree of illumination of the solar spectrum, we shall find that green lies next to yellow in degree of illumination.

Again, the contrast between the light reflected from green and ordinary diffused daylight is less for the eye than the contrast between light reflected from any other color and diffused daylight.

These facts would seem to lead one to favor some greenish color for the walls of a schoolroom. A light green gray, as near to white as possible, is recommended. The light greenish gray should be soft and not harsh. It may be produced by the proper combination of pigments. Antwerp blue and raw sienna with white as a base will give the proper tint.

The walls should in every instance be painted, in order that they may be washed. There should be no gloss, and the paint when put on should be stippled to prevent all reflection.

The ceiling should be white, in order that the least possible amount of light may be absorbed by it.

The color of shades and their arrangement — The color of the shades should be the same in tone as that of the walls, but somewhat darker. The shades should be opaque, and it may be remarked that not only can a better color be secured when the shades are tinted (water-color wash), but such shades are more durable and give less trouble from continued wear in rolling up and down than holland shading. The opaque shades are for the purpose of excluding the light at times when the light is dazzling, as on a sunny day with the earth covered with snow, and at other times when it is necessary to temper the effect of light in the schoolroom. These shades should roll up from the bottom of the window, in order to exclude the light from the levels just above the pupils'

eyes first, leaving the upper part of the window open so that the light may be more evenly diffused through the room by coming in near the ceiling.

The plan quite widely adopted of having two shades to a window, one for the upper half and one for the

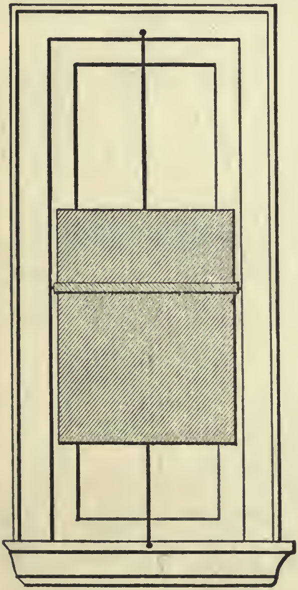


FIG. 7.

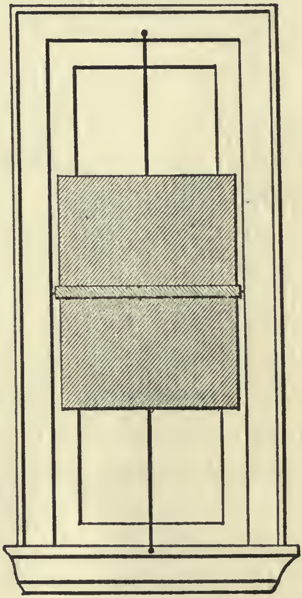


FIG. 8.

lower half, rolling up and down respectively from two rollers hung across the middle of the window, is to be condemned. This plan for excluding light invites, of itself, an abuse of hygienic conditions. Light is usually excluded with the shades drawn as in Fig. 7, or as in Fig. 8, thus producing strata of light and half

shadow, a condition which, for reasons already given, is injurious to the eyes.

Venetian blinds are not to be tolerated in the schoolroom, as they admit bands of high light in alternation with dark bands of shadow — a condition extremely deteriorating to vision. They are, moreover, collectors of dust.

If it is necessary to exclude the direct rays of the sun, a translucent white shade may be placed inside the opaque shade, to roll down from the top, as recommended by Marble.

Direct rays of sunlight should never be allowed to fall on a desk at which a pupil is sitting, as the intense light in contrast with the comparatively softer illumination of the room irritates and weakens the eyes.

Arrangement of desks — In Fig. 2, p. 5, a plan for the seating of the schoolroom is given. It will be noticed that the whole body of seats is placed as near the light as possible. The aisles alongside the windows are, for this reason, made as narrow as permissible. This affords the additional advantage of securing a wider aisle near the blackboard. The wider aisle gives space for pupils to pass those who may be working at the blackboards, and it also affords space for other school exercises.

Earlier in this chapter reference was made to the disadvantages of seating pupils so as to face the long side of the room. It will be seen by comparing the plan of

seating shown in Fig. 2, p. 5, with the plan shown in Fig. 9, that those pupils who sit in the outer row of seats on each side of the room in which the desks face the long side of the room are at a disadvantage as to distance and the foreshortened view under which they

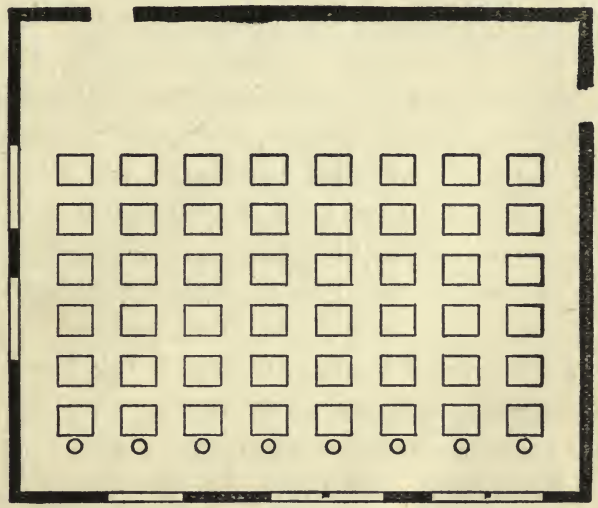


Fig. 9.

are obliged to look at any object, such as a piece of apparatus of any sort on the teacher's desk, a map behind the desk, or any illustration or explanation put on the blackboard.

Blackboards — The slate blackboard is to be preferred to any other kind, as it can be washed without injury, and thereby the sifting of deleterious crayon dust into the air be somewhat lessened. Various shades of slating are offered by school supply dealers,

but grays and brownish blacks are to be avoided. The slate chosen should be either green or a strong black.

When slate is not used, blackboards can be made by pasting tough manila paper of suitable thickness on the wall and then painting and slating this. If the paint and slating are of a dark green color, the effect will be found very pleasant to the eye, and the legibility of white crayon thereon will prove fully equal to its legibility on a slate board.

There cannot be too much blackboard in a schoolroom. The sending of pupils to the blackboard to write various exercises affords pupils a most necessary relief from the cramping and tiring positions of even the most approved hygienic desks. If it is found that blackboards around the entire room, where the wall space permits, absorb too much light, or give the room an appearance displeasing to the eye, shades of the same tint as the walls may be arranged on spring rollers of convenient length, to be drawn down over the entire blackboard or the parts not in immediate use.

For primary grades, the blackboards should be placed 26 in. from the floor. For intermediate grades they should be placed 30 in., and for grammar grades 36 in., from the floor. All boards should be 4 ft. wide.

Every blackboard should be provided at the bottom with a trough 2½ in. wide. The trough should have

an open woven wire cover, with $\frac{1}{4}$ in. mesh, set with hinges. The object of this cover is to permit the crayon dust to fall through it into the trough, and so lessen to the greatest degree possible the stirring up of crayon dust by those who are working at the blackboard. At regular times the covers should be raised and the troughs thoroughly cleaned.

A platform for the teacher's desk and chair is unsanitary, as dust and dirt collect behind and underneath it. Because of its interference with the free movement of pupils at the blackboard behind the teacher's desk, the platform has been almost wholly discarded from the class-room.

CHAPTER II

The School Building

The value of thorough construction and planning — The school building should be constructed of the best materials put together in the most substantial way and with the very best workmanship available. Thorough construction of the very best material is in the end the most economical not only of money but of time. By building thoroughly and substantially, the day of repairing or altering is put off to the utmost. It is well for school authorities to remember when they set about the erection of a new building, that in all probability it will stand for forty or fifty years and perhaps longer, and that therefore only the very best and, at the same time, most thoroughly approved ideas as to planning, construction, and equipment should be embodied. Too often school authorities do not give themselves sufficient time in which to build thoroughly and substantially; for the determination of what, in these days of rapid progress, are the most approved advances and the reasons therefor, consumes a great deal of time and renders the planning and erection of a new school building a laborious undertaking. Un-

looked-for difficulties arise in regard to modifying, adapting, and adjusting, which call for the most careful and painstaking examination, if the wisest decision under the circumstances is to be reached. As is too frequently the case, a new schoolhouse is so urgently needed, that in the haste to erect one many defects are allowed to pass, while others are overlooked. The demand for school accommodations may be exceedingly urgent; but even under urgent demands months of waiting is advisable if in the end as perfectly planned and thoroughly constructed a building as possible is erected. When it is remembered that the building will in all probability stand for at least a generation and a half, the enduring of crowded conditions for a time longer is a matter of comparatively lesser moment; but a defective building, entailing discomfort as long as it stands, is always an object of criticism, and a source of regret on the part of those responsible for it. Conditions are never so bad but that they may be relieved to a considerable extent and endured somewhat longer, especially if provision for the best accommodation is being made. In no case should the building be hurried; neither, on the other hand, should its construction be permitted to drag along and an unjustifiable length of time be consumed in its erection.

If possible, the school building should be built of brick or stone, having as many of the interior walls as possible of brick. The danger from fire in school

buildings which are constructed of wood is so great as to debar the erection of wooden buildings in every community, except perhaps in small country villages, where, as a rule, the extra expense for brick construction could not be met.

Position of building — The school building should be so placed that there may be a free circulation of air about it. It should be as far back from the street as possible to avoid dust and noise, but a position well back from the street must not be given it if such a position would bring the building near other buildings in the rear, and cut off the light. The rule has been laid down that a line drawn from the foot of the wall of the school building to the top of the nearest building should not make an angle greater than thirty degrees with the horizon. When conditions will possibly admit of this, it will be found to promote in a most satisfactory measure the well-being of the successive generations of pupils. For not only does the observing of this requirement insure much better-lighted rooms, precluding injurious effects upon the eyesight of pupils, but rooms from which an expanse of sky may be seen are more conducive to cheerfulness. Rooms shut in by neighboring buildings exert a depressing influence upon the minds of those obliged to occupy them.

In addition to the foregoing suggestions as to the position of the building, it is further held that the

building should stand so as to receive as much sunlight as possible. Some authorities recommend that the building should stand so that the direct rays of the sun may enter as many class-rooms as possible some time during the hours of sunshine. The recommendation is an excellent one, for the sun not only imparts cheerfulness, but is nature's purifier. Direct sunlight, it is well known, acts as a disinfectant, arresting the spread of infectious diseases. Infectious germs of most diseases do not grow and multiply in cultures made in direct sunlight.

It will be evident, then, that trees should not stand so as to overshadow any part of the building, as they not only cut off light necessary for sufficient illumination, but render the rooms damp and, therefore, unhealthful.

Number of stories to be limited — Dr. Lincoln holds that it is desirable, where possible, to limit the height of the building to two stories above the street. On hygienic grounds there can be no question that a school building should not exceed two stories in height. Especially is this limitation to be regarded in the case of high schools and schools conducted on the department plan, as in this type of school pupils must pass from the lower to the upper floors several times a day. With buildings three and four stories high, as is often the case, there is a strain imposed in climbing so many flights

of stairs, which is injurious to all pupils, and especially so to girls.

Basement — There should be a basement under the whole building. Its walls should rise sufficiently high from the ground to permit thorough lighting, and if possible the entrance of the sun's rays. The basement should be carefully protected against dampness. In order to secure this, the walls of the basement floor must be so constructed as to be impervious to the passage of water or moisture through them. In the construction of the wall a layer of asphalt or a layer of tarred paper well covered with coal tar should be placed between the layers of bricks on a level with the lower side of the basement floor. The outside of the walls should be asphalted or thoroughly covered with coal tar from the layer of asphalt or tarred paper between the bricks up for sufficient distance above the ground so as to prevent the spatter from rain and melting snow from imparting moisture to the bricks.

The bottom of the basement should be filled with broken stone and cement up to the level of the asphalt which has been placed in the walls, then a coat of asphalt should be spread over this concrete floor to join with the layer of asphalt or tarred paper placed in the foundation walls. It will readily be seen from Fig. 10, p. 35, how by this plan moisture may be kept from entering the build-

ing through the foundation walls and basement or cellar floor.

In buildings with a basement, if this is used as a playroom or for students to pass through, hygiene requires that it should not have a cement floor, as

FIG. 10.

the cement wears off while the children are playing or marching, and the air becomes filled with a heavy dust that is especially deleterious. The floor should be of asphalt or of some hard wood.

Experience has shown that a large number of the fires in school buildings originate in the furnace room, which usually occupies a part of the basement. In order, therefore, to provide as much security as possible against disaster in case of fire, this room should be fitted with iron doors to shut it completely off from the stairways and rest of the building.

Wooden school buildings should have a foundation wall at least two feet above the ground; and if there is no basement or cellar, provision should be made for thorough ventilation underneath.

Entrances — The school building ought not to have less than two entrances, and if the school is located in a closely populated city there should be as many entrances as possible, a number sufficient to permit, in cases of emergency, the depletion of the entire building in three minutes. The entrances to a city school ought to be wider than the stairs which come down to the entrances, so as to relieve the pressure when in cases of accident it becomes necessary to deplete the schoolrooms in the shortest possible time.

In a well-planned building every entrance for pupils will be provided with a vestibule and storm doors to protect children who come early, and in cold and windy weather to prevent the wind blowing directly into the corridors and producing strong draughts.

Corridors — A serious mistake too often made in the construction of school buildings is that of allowing an insufficient amount of space for the halls or corridors — of cutting these down to the narrowest limits, and thus imposing additional difficulties upon teachers and pupils as to ingress and egress. It seems a difficult matter for those intrusted with the erection of school buildings to realize the importance of making the halls or corridors sufficiently wide. The main corridors or halls of a school building ought to be at least 10 ft. in width, and 12 ft. will be found a more satisfactory width. But while too narrow halls are to be emphatically con-

demned, excessively wide halls, on the other hand, are to be avoided. Very wide halls are occasionally seen in school buildings, and, besides the original increased cost in construction, they entail additional expenditure to keep clean the unneeded floor space and to warm and ventilate the unneeded air space.

The corridors or halls of most school buildings receive too little light. Special care should be taken to have them thoroughly lighted by direct light from large windows at the ends of the halls. If the halls are long, then light should be introduced from the adjoining schoolrooms through large windows. The sills of windows for lighting the hall should be 8 ft above the floor. One caution, however, as to the kind of glass for these windows needs to be stated. Transparent or factory ribbed glass should be used, and not ground glass, as measurement shows that about seven-tenths of the light is lost in passing through ground glass.

The doors at the entrances of the building should open outward.

The doors which connect the class-rooms with the corridors should be 3 ft. 6 in. wide for the standard schoolroom.

Stairways — There should be at least two stairways in every school building, and these should lead directly to the upper floor of the building. The plan of having in three-story buildings two stairways up

to the second floor, and but one stairway from the second floor to the third floor, is exceedingly dangerous — as this stairway might easily be cut off in cases of fire, and a shocking loss of life ensue.

In mixed schools, one stairway should be assigned to boys and another to girls. Separate stairways in mixed schools are a right of the community on moral grounds. Special care should be exercised on the part of the architect not to place these stairways in the centre of the building. Such an arrangement is most hazardous in case of fire. The stairways, therefore, should be at the ends or sides of the building, and should be easily accessible from the contiguous class-rooms.

It has been strongly urged that stairways should not be constructed with balustrade, but should be of a form called box stairways, thus precluding the possibility of children's falling over the banisters in cases of hurry and excitement in getting out of the building. The record of accidents with open stairways is made the ground for this recommendation. There are other authorities who hold that box stairways are unsightly, and that the balustrade may be built sufficiently high to preclude the possibility of accidents.

Whether the stairways are of the box or the balustrade pattern, there should be a hand rail on each side sufficiently low that it may be grasped by the

smallest pupils that pass up and down the stairway. Many schools in which small pupils must ascend stairways have two hand rails, the lower one for the safety of smaller children, and the upper rail for the use of the larger scholars.

Wherever in the erection of a school building it can possibly be effected, stairways should be built of iron with slate treads or treads made of steel and lead. Such stairways are not combustible, and are not a positive source of danger in case of fire.

We have already spoken of the fact that halls or corridors are not sufficiently lighted. The same fact is true of stairways in most school buildings. It is overlooked that most light is needed when the stairways are filled with the children in passing in and out, and that at these times there is the greatest absorption of light.

The stairways ought to be at least 5 ft. wide, and each stairway should be broken by a square landing, or better by an oblong landing. This landing should break the stairway as near as possible in the middle, but in any event not less than eight steps ought to be permitted between landings. A less number is a temptation to jump the entire distance. The landing not only affords rest for the muscles of the child in climbing the long flights, a very important matter in itself, but it is also a guard against accidents. At each floor, where the stairway terminates, there should

be a long landing. Under no circumstances are diagonal steps permissible in a school building. The constant danger of accident from these determines why they cannot be allowed. It will be seen that the same objections, although in greater degree, stand against the construction of any spiral stairway in a school building.

Height of risers and width of treads—The stairs in all school buildings should be easy for children to pass up and down. This is a question, therefore, of the child's requirements and not the requirements of adults, and must largely be determined from the point of view of the child's needs. The matter turns upon the height of the risers and the width of the treads. Under no conditions should the risers, that is the perpendicular distance from one step to the next, exceed 7 in., and this will be found too high. From 6 to $6\frac{1}{2}$ in. is the proper height. It will be seen that in high schools stairs may be constructed with the risers $6\frac{1}{2}$ in. high. In school buildings for grammar and primary grades, the risers should be 6 in. and the treads not greater than 12 in., care being taken that the nosing of the treads does not project more than $1\frac{1}{4}$ in. beyond the plane of the risers. If the nosing is wide it is equivalent to reducing the width of the tread, and requires an effort of attention on the part of the pupil in ascending, to prevent catching the toe on the edge of the nosing.

It is held that stairs with 6 in. risers and 11 in. treads are the easiest for children.

Floors — The floors of the school building should be constructed of maple, birch, or oak, to be serviceable and to prevent excessive spread of the particles of wood in the atmosphere of the school room, due to constant wear. Maple and birch, however, shrink and swell considerably under certain conditions. Red oak has been found to give good satisfaction. First quality comb grain Georgia pine makes good floors, but so much pine is sold under that name that, unless special precaution is exercised, a grade of pitch pine is likely to be used that slivers and thus forms openings for the constant collection and diffusion of dust. After a year's wear such pine takes on an unsightly appearance which constantly grows worse in this respect as long as the floor lasts. If Georgia pine is used it will be rendered more serviceable if two coats of linseed oil are applied to it. The filling of the cracks of the floor cannot, on hygienic grounds, be too strongly urged. The junction of the floor and wainscoting or surbase should be finished with a cove as shown in Fig. 11, so that sweeping and cleaning may be more quickly and thoroughly done.

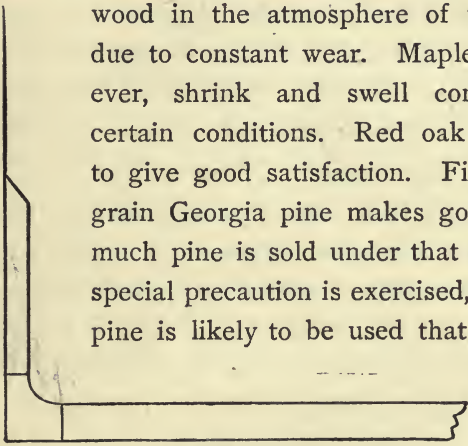


FIG. 11.

The floor of a school building should be sound proof. This is only partially accomplished by laying double floors with felt paper between. To render floors thoroughly sound proof, the beams should be filled in with mortar.

Trim and walls — As so much emphasis has been put upon the utmost possible exclusion of dust from the school building, a word must be added in regard to the walls and the trim over windows and doors. X The junction of the walls and the ceilings should be concave, finished in a form similar to that recommended in regard to the junction of floors and wainscoting. All cornices, mouldings, and ledges of whatever kind, upon which dust may fall and collect, must be unhesitatingly rejected in determining the interior finish of the building.

The walls should not be covered with paper, as this gathers and holds dust; but they should be painted so that they can be washed.

Attic floor — If the school building has an attic, it will be found advantageous on grounds of economy and comfort to cover the attic with a floor. When an attic is not floored great waste of heat results, due to the rapid radiation from the ceilings and the walls in winter, besides the fact that the walls become cold enough to interfere with the ventilation of the rooms. In hot weather these walls and ceilings become heated from the roof, and render the

rooms under them much warmer than if the attic were floored.

Wainscoting — Objections have been raised in the last few years to wooden wainscoting on the ground that it is unsanitary, and a finish of cement mortar has been recommended, even along corridors and stairways. Such a finish, however, even when put up in the best manner, becomes in a short time dented and broken from the usage to which it is subjected, and presents an unsightly appearance. In the newer school buildings in Scotland and England, the unsanitary character of wood wainscoting and the lack of durability of cement mortar are obviated by using glazed brick or tiles. While such a finish is to be thoroughly approved, its use to any great extent in this country will be prohibited by its large expense.

Cloak-rooms — Every primary and grammar school should be provided with a cloak-room for each class-room. These cloak-rooms should connect with the hall and with the class-room. They should be lighted from the outside, and should be heated and thoroughly ventilated, so that odors arising from the clothing may be carried off, and the clothing be dried in damp weather. A cloak-room, the proper size for a standard class-room, should contain 150 sq. ft. of floor space. In many school buildings hat and coat hooks are put in the corridors or halls, and pupils' clothing is hung there. Such a method of

providing cloak room is to be strongly condemned, not merely on the ground of the unsightly appearance which the halls of the school building present, but because of the odors emanating from the clothing, and the danger of infection from disease. The basement, moreover, ought not to be used as a cloak-room.

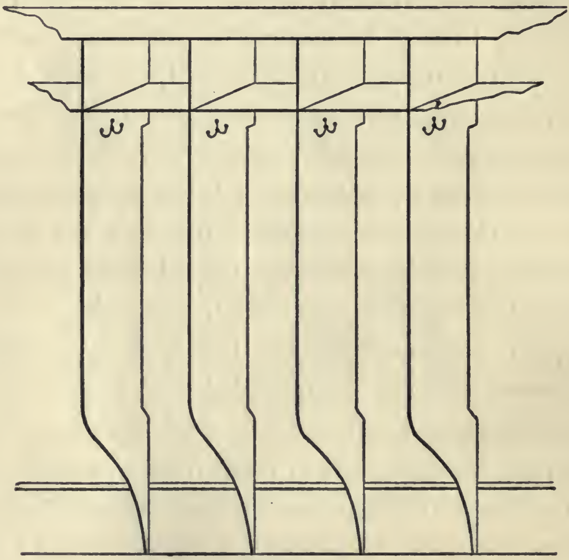


FIG. 12.

In the best-equipped schools, cloak-rooms are fitted up in either of two ways. According to the first way, a shelf 15 in. wide, thoroughly supported by strong brackets, runs around the walls of the room 5 ft. from the floor. On the under side of the shelf, 15 in. apart

and about in the middle of the shelf, double coat-hooks are screwed. A full circulation of air about clothing hung on hooks so arranged is afforded. It therefore dries quickly. Hats may be placed upon the shelf above the individual hooks. The second way is shown in Fig. 12. A series of compartments is made by placing boards 10 in. wide and 10 in. apart vertically around the walls of the room. The uprights curve in at the bottom so that the cloak-room may be easily swept. They are also blocked out from the wall to allow some circulation of air behind the clothing. A shelf rests on the top of the uprights. Ten inches below the shelf are shelves between the uprights. On the lower shelf the pupil may put his lunch basket or his overshoes.

The second way has some advantages from the point of view of the individual pupil, but from a sanitary point of view it is perhaps a little less satisfactory than the first.

Disposition of rooms — In the description of a standard schoolroom in the first chapter of this book, the opinion was promulgated that a school building should be conceived from the point of view of enclosing the number of standard schoolrooms required, with corridors, cloak-rooms, and other accessories, rather than from the point of view of first determining the size of building that could be erected for the appropriation, and then proceeding to divide it up into class-rooms, cloak-rooms, and corridors, as the amount of space would permit. In other words, the first thing to be

considered in the planning of a school building is the disposition of the required number of schoolrooms, and after this the planning of the outer walls and the roof of the building. In Fig. 13, a floor plan of a school building with four rooms is shown. By observation of

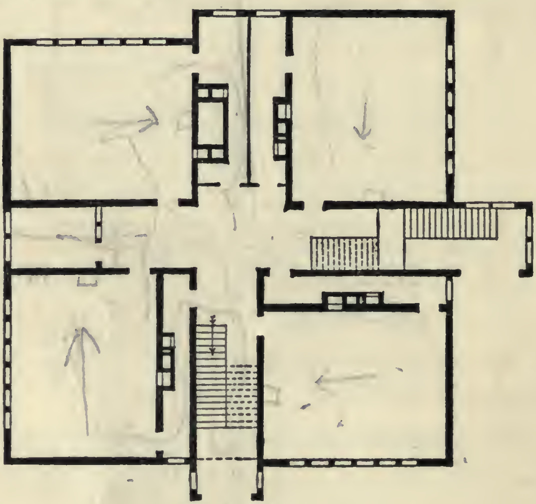


FIG. 13.

the plan it will be seen that the length of one room is perpendicular to the length of the contiguous room. Such a plan admits of the introduction of the great mass of light from the left of the pupils, besides possessing the advantage that the pupils face the long way of the room, a method of seating the reasons for which have already been given in Chap. I. Compare now the plan shown in Fig. 13, with a typical plan of build-

ings with four rooms on a floor, frequently met with, as shown in Fig. 14. In the last plan the pupils would be seated facing in the direction indicated by the arrows. It will be seen, then, that in rooms 1 and 4, the aisles between the seats run the short way of the

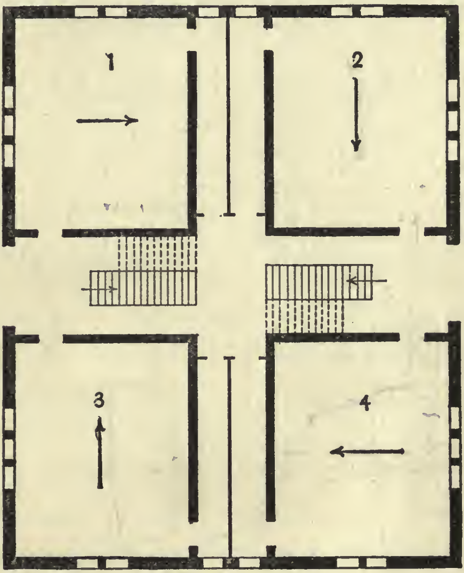


FIG. 14.

room, and the great amount of light comes from the rear, and the illumination on the pupil's book or paper is lessened because the light is intercepted by his body. In rooms 2 and 3, the greater amount of light comes from the left, and the aisles run the long way of the room. One-half the pupils, then, on this floor, by virtue of the plan, are subjected to conditions deteriorating to eyesight.

Defective floor plans — We give, now, a few sketches of what we regard as defective plans of school buildings, pointing out the defects of those plans. The plans are taken from printed reports of Boards of Education, and from educational journals. They are

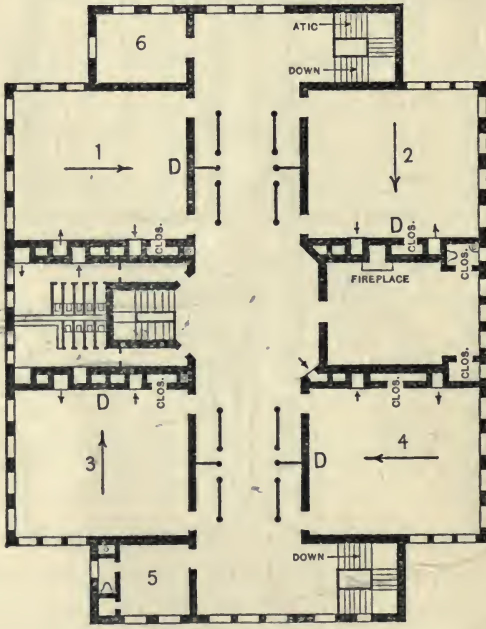


FIG. 15.

all of buildings recently erected, and from widely separated parts of the North and West. The elevations are purposely omitted.

An examination of the plan shown in Fig. 15 shows, first, that when the other conditions are considered

there is an undue amount of space given to the corridor. It will be noticed, further, that instead of cloakrooms small places are partitioned off in the halls for wardrobes, two for each room, one being appropriated for girls and the other for boys. These enclosures for hats and coats and wraps are without ventilation other than the ventilation of the corridor; they are conspicuous and unsightly in appearance, and reduce the proportions of the corridor to the eye.

It will be noticed upon further examination that the stairways have two landings. They need have but one landing, and might begin nearer the doors of the adjoining class-rooms, and thus insure a quicker, easier, and safer exit of pupils from the building. Judging from the plan, one of the stairways is not as well lighted as it might be.

The class-rooms numbered 1, 2, 3, and 4 are 28 × 32 ft., with ceilings of 12 ft. They are lighted, it will be observed, from two directions. These rooms are too large, especially with ceilings of 12 ft., and fully a fourth of each room, the parts of the rooms near the corridor, are insufficiently lighted. In order to bring the light from the left and the rear, pupils would have to be seated facing in the direction shown by the arrows, the teacher's desk in each room being indicated, in the drawing, by the letter *D*. It will be noticed, therefore, that in rooms 2 and 3 the pupils would be seated with the aisles running the short way

of the room, a plan of seating which is objectionable for reasons given in Chap. I. Furthermore, it is evident that some rows of desks and parts of rows would be placed in those parts of the room having insufficient light. In rooms 1 and 4, the light coming from the rear overpowers the light coming from the left. But this is the only way in which the rooms can be seated without having the light come from the right or having the children face the light. In rooms 1 and 4, then, since the light coming from the rear overpowers the light coming from the left, the pupil would be working continually in a shadow cast by his body. It will be seen, moreover, that the teacher would have to face this light a great deal of the time, and would thus be subjected to conditions very taxing upon eyesight.

If some of the space given to the corridor had been taken and added to a space 2 ft. wide taken from each room, fair-sized cloak-rooms contiguous to each class-room could have been formed.

The room marked 5 is a teachers' room, and the room marked 6 an emergency room. The plan of having an emergency room for the reception of pupils in cases of sickness and accident is to be highly commended. Every large school without an emergency room is defective in its equipment.

In Fig. 16, there is shown a floor plan of the second story of another school building. The class-rooms in the plan are marked 1, 2, 3, 4, 5, and 6.

They vary slightly in size, but are approximately 25 × 32 ft. The cloak-rooms are marked 7, 8, 9, 10, 11, and 12. Room 13 is a reception room. The corridor

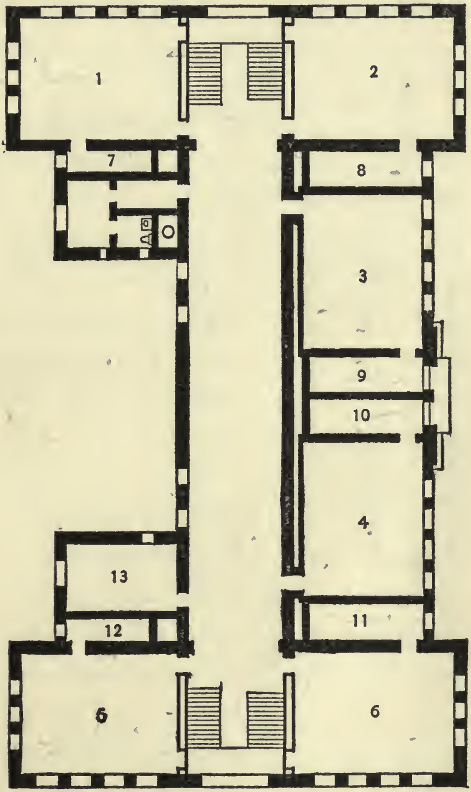


FIG. 16.

is 16 ft. wide, and unless lighted by a large number of windows in partitions dividing class-rooms from the corridor, would prove too dark.

It will be seen from what has been said of the previous plan that rooms 2 and 5 seat badly. The light from the rear overpowers the light from the left,

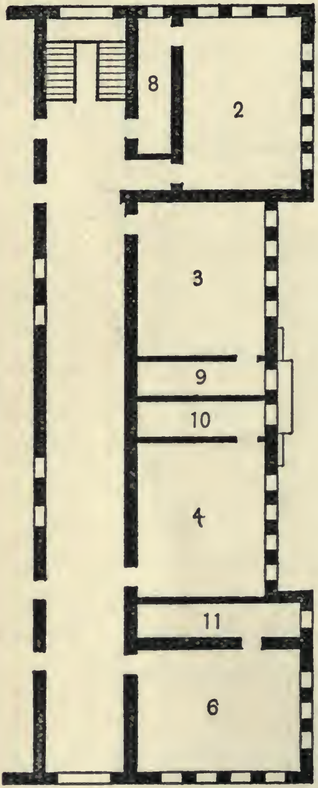


FIG. 17.

causing the pupils always to work in a shadow cast by their bodies on the printed page, copy-book, or pad. All the schoolrooms are too long for pupils in the rear seats to see the blackboard behind the teacher's desk when seats are set so that the aisles run the long way of the room.

It will be noticed that pupils must come from the corridor into the schoolroom with their wraps on, and then pass into the cloak-rooms. A door leading from the corridor into the cloak-room, with a door leading from the cloak-room into the class-room, under ordinary circumstances seems to be preferable, as the entrance of the class into and its exit from the schoolroom are thus effected more conveniently and in better form.

The defect spoken of in regard to rooms 2 and 5, in which the light from the rear overpowers the light coming from the left, thus obliging the pupil to work in a shadow, could have been remedied by a disposition of the cloak-rooms as shown in the sketch of one-

FIG. 18.

half of the building given in Fig. 17. Such a plan leaves a small lobby at the entrance of room 2, but this arrangement is not inimical to eyesight, and is far less objectionable than having pupils sit so that they work in the shadow cast by their bodies, as when seated so that the aisles run the short way of the room.

In Fig. 18 is shown another floor plan of a recently erected school building. The class-rooms are marked

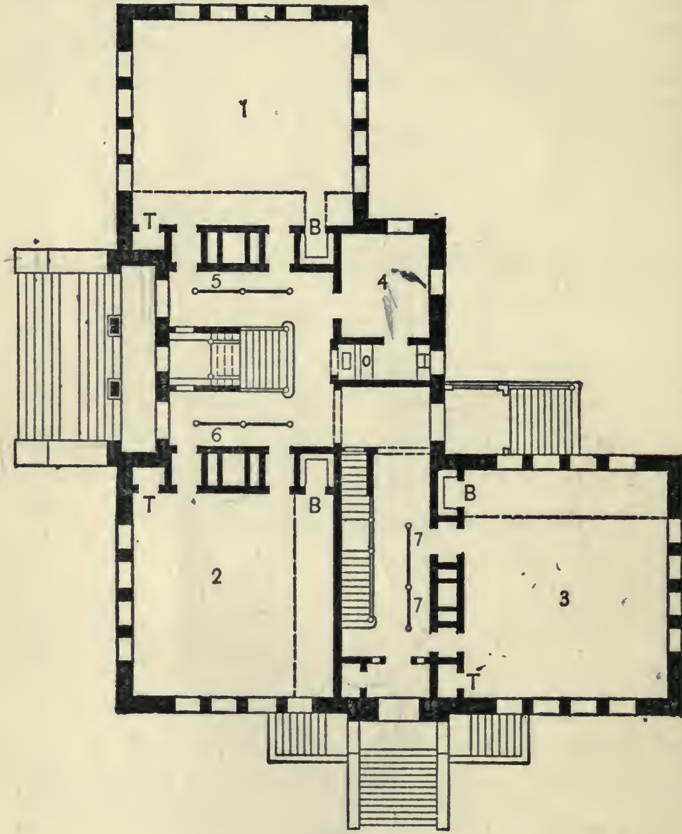


FIG. 19.

1, 2, 3, 4, and 5, the corridor 8, the library 6, the principal's room 10, and the lobbies 7 and 9. The class-rooms are 24 ft. 6 in. wide by 32 ft. long; the cor-

ridor is 16 ft. wide. It will be seen that the corridor is badly lighted, and that there are no cloak-rooms, but narrow wardrobes inside the class-rooms. It would seem as if the lobby rooms were unnecessary, and that the space devoted to them, together with some of the space of the corridor, could have been appropriated for cloak-rooms, which even then would have been smaller than is desirable, but greatly preferable to the narrow wardrobes.

The class-rooms would be seated with pupils facing in the direction shown by the arrows. It will be seen again in this plan that in two rooms, 1 and 4, the rear light overpowers the light from the left. The illumination also in room 3 is very poor. Two-thirds of the room has no window admitting light.

We add another first-floor plan of a recently erected building, Fig. 19, p. 54. Rooms 1, 2, and 3 are class-rooms; 4 is a teachers' room, with toilet adjoining; 5, 6, and 7 are the wardrobes; the closets marked *T* and *B* are respectively for the use of the teacher and for books. An examination of the plan shows that the halls are crowded, and that if the wardrobes, to which the same objection can be made as in the plan shown on p. 48, Fig. 15, were removed, the corridors would have sufficient space. The stairways are too much in the centre of the building. The rooms are larger than necessary, being about square in shape rather than oblong, and therefore, unless a large amount

of space is allowed for each pupil, not so convenient for the order and direction of the school as an oblong room. Two of the class-rooms, it will be noted, are lighted from three directions, an arrangement which cannot be recommended. The building, it may be stated, stands at the corner of two streets, and at the side and rear the light is not cut off by high buildings. In what direction the building faces is not known from the plan. Under general conditions, however, even with careful use of shades, it is possible that the light in most of the rooms would come in more strongly from the rear or from the right side than from the left side. The schoolrooms might safely have been made oblong in shape, and some of the space given to them appropriated for cloak-rooms. It is plain from further study of the plan that a partition might have been run along the whole length of the side of schoolroom No. 2, as indicated by the dotted line, and an entrance to the hall made where the book closet is now placed. The same thing could have been done in schoolroom No. 3, as indicated by the dotted line. In schoolroom No. 1 the cloak-room could have been thrown across the side of the schoolroom, as shown by the dotted line. The space beyond the proposed cloak-room, together with the space given to the book closet, could have been thrown into the corridor, and the entrance to the schoolroom made here, leaving near the wall a small

book closet, as indicated by the dotted line. The windows in the wall which extends from the proposed book closet could then have been omitted, and the pupils could have been seated facing this wall. The light would then have come from the left and rear, and the aisles between desks would have run the long way of the room.

The changes suggested in this plan would afford plenty of wall space for well-lighted blackboards. The lack of such space in rooms 1 and 3 as shown in the plan is a striking defect.

CHAPTER III

School Grounds

Centrality of location — In the selection of a school site, centrality of location with reference to the school population must be first considered. The point involved here is convenience of distance for the greatest number of pupils. There are, however, several other factors which must be taken into consideration besides centrality of location.

Site away from noise and polluted air — In the first place, a site well back from the street is to be desired. In a city, especially if it is a crowded one, a main street should be avoided. The school site must not be chosen near industries which render the air in their neighborhood charged with various gases, smoke, or smells. The site, moreover, should not be near noisy industries or a railroad. It should not be near any place where much dust is being continually stirred up, nor should a site be chosen from which filthy neighborhoods or dilapidated buildings come into view; neither should the site be in proximity to any neighborhood where degradation or immorality of any kind is likely to be witnessed by pupils on the playground or from the

windows of the school building. In the country, the site chosen must not be in the neighborhood of a swamp, a marsh, or stagnant water. Carpenter says that the neighborhood of rank vegetation is to be avoided, as it indicates an impure soil.

Character of the ground — The character of the ground of the school site is also to be considered in the matter of selection. The ground chosen should be well drained naturally. It should be pervious to water. The soil should not be damp, as dampness conduces, it is believed, to catarrh and other ailments. A clayey soil is to be avoided from the fact that there is moisture continually rising from it, and there is a peculiar coldness to the air above a clayey soil. The soil must be free from ground water, or water which collects in the interstices of the soil. Sometimes in rocky ground this water collects in pockets formed of rocks, and becomes stagnant. A site having much ground water, unless this can be thoroughly remedied by careful drainage by means of pipes laid underground, should be abandoned. The recommendation has been made that if the ground water is found nearer than 15 ft. below the surface, it should be uniform as to its level, and not subject to rise at intervals. If the ground water rises and falls, such conditions must receive very careful consideration before a decision is reached as to the selection of such a site. By digging a hole, the level of the ground water may be ascertained, and also the further fact as to

whether it rises and falls. Its highest level, it is claimed, must not be less than 3 ft. below the level of the basement floor.

Draining — If there is no other ground than springy soil available for the school site, the ground about the building may be drained by digging a trench around the foundation walls but far enough from them for absolute safety, and laying in this trench drain tile with loose joints. The drain tiles should discharge away from the building, and should be laid a considerable distance below the cellar floor, as cementing the cellar floor or wall will not effectually keep out ground water.[1]

Soil free from organic matter — The soil of the site chosen should also be free from organic matter; hence, made soil or marshy ground should not be selected. Little as we are given to regarding such conditions, they exert a marked effect upon the air above such ground, and also upon health. Besides the moisture rising from such soils, they contain a considerable amount of contaminated air. They are all porous, and such soils become charged with what is called ground air. This is led upward through the floor of the building, either by the warmth of the building or on account of the rising of ground water, and is a source of considerable danger to health. It is not necessary here to call attention to the pollution of the ground from sewers and other contaminations

[1] Lincoln.

so common in cities, as one's own senses have rendered these facts sufficiently impressive; but I regard it necessary to dwell to some extent upon the atmospheric pollution of the ground, as the reasons why there is such pollution are not as widely known as they should be. The air finds its way into the soil from atmospheric pressure and the processes of diffusion. The falling of ground water after it has risen draws, as will be seen, air back into the ground.

Composition of ground air; its exclusion — As a result of various analyses of ground air, it has been found that such air undergoes many changes, and its composition is markedly different from that of the normal atmosphere. The most conspicuous alteration that air undergoes in the soil is in the large percentage of oxygen that disappears. A short distance below the surface, the proportion of oxygen has been found as low as 7.4 parts per 100 of air instead of 20 parts approximately, as found in the atmosphere. The oxygen which has thus disappeared has been appropriated by micro-organisms that exist where processes of fermentation and decomposition are going on. Again, in the various analyses of ground air to which I have referred, carbonic acid gas, CO_2, has been found to be present in amounts which vary from 0.2 per cent to 14.0 per cent, instead of 0.04 per cent as in the normal atmosphere. Coating the outside walls and bottom of the basement with coal

tar to render the wall impervious to moisture, as recommended in Chap. II, p. 35, serves also to exclude the passage of ground air into the building.

Elevation of site and grading — The site chosen should be elevated, but should not be on the slope of a hill, if this can be avoided. If the school site has to be chosen situated on a slope, grading and draining should be provided so as to prevent the flow of ground water or rain toward the foundation. The site should therefore be so graded as to slope away from that side of the building toward which the land sloped before grading, and drain tile should be so placed as to carry away the water.

The school site, wherever situated, should be so graded as to slope away from the building on all sides. The slope ought not to exceed 1 in. for every 3 ft. One authority recommends 3 in. of slope to every 10 ft. If the school site is located on a long slope, then the site should be so graded that there shall be a slope from the building toward the higher ground.

Size of site — In determining the size of the site, the amount of space that should be given to playground is the first point to be considered. A space of 3 square metres for every child is the standard most frequently recommended in Germany. Professor Burnham of Clark University, who has given great attention to this point, concludes that in this country 30 sq. ft. are

necessary for each pupil, to meet all the demands of play. According to this standard, a school of a 1000 pupils would require a piece of ground 300 by 100 ft., that is, twelve city lots, for playground alone.

The site should be large enough to admit of some ornamentation of the grounds, especially in front of the building, in order that the influence emanating from the cultivation of the beautiful be not overlooked. However, as between space for playground and space for ornamentation, other things being equal, there can be but one conclusion held, namely, that games are immeasurably superior to ornamentation, in conducing toward mental development alone. When we put with this the benefits accruing to health in sacrificing room for ornamentation to playground, the conclusion reached in favor of playground has additional strength. The playgrounds should be on the sunny side of the building, and be sheltered from cold winds by the building, and by evergreens and a hedge if this is admissible. If evergreen trees are used for protection from winter winds, these should be placed at a sufficient distance from the building so as not to cut off light from the schoolrooms in any degree whatever. In cities where land is very costly, the roof of the building may be utilized for a playground. For the full purposes of play, if there is no gymnasium connected with the school, there should be on the playground covered sheds for play in rainy weather.

Covering of the playground — The school site may be covered with natural gravel, or in some places with asphalt. Gravel has the advantage of being clean, and ground so covered may be frequently sprinkled to avoid dust. Sand mixed with gravel has been suggested. A hard covering to the playground, such as hard asphalt or stone flagging, has the disadvantage, as has been pointed out by a French authority, of restricting children in their movements, and thus depriving them of full opportunities for the coördination of muscles, and the more exact and perfect development of their physical powers. Jumping, which is likely to be indulged in by boys, and girls as well, leads to more or less injury when the surface upon which the pupils jump is hard and unyielding, as in the case of flagging or very hard asphalt.

Entrances — The entrances to the school grounds should be ample, so that egress and ingress of pupils may be rapid. There should be separate entrances for boys and girls.

CHAPTER IV

Warming and Ventilating

Steam and hot water systems—For warming school buildings steam heat is regarded by many as the most convenient, the most economical when cost of installation is counted, and, taking all factors into consideration, the most satisfactory means. Steam requires a less amount of pipe and radiating surface than hot water. As it is an intense heat, rooms can be more quickly warmed. Steam radiators can be shut off in rooms not in use, and there is much less danger from frost than in a hot water system. Others hold that hot water heating is much to be preferred. The heat coming from hot water radiators can be the more evenly regulated, it is less intense, and therefore more agreeable. The cost of installing a hot water system is, however, greater than the cost of installing steam, and requires more careful workmanship. But it is claimed that after the cost of installation, the hot water system can be operated at a considerably less expenditure for fuel. The tests which have been made between the amount of fuel required for steam heating and for hot water

heating must, on the whole, be regarded as favorable to hot water.

Steam has the advantage, when the pressure is high enough, of being available as a means of power for driving the ventilating fans, and it has been found in certain cities that the exhaust steam from the engine used to drive the fan is one-third of the amount required to keep the building at a proper temperature. If, however, the building is heated by a low pressure system, the steam is not available for propelling the fans.

It is not the purpose in this book to enter into any discussion of steam fitting. Steam heating and fitting, as a branch of mechanical arts, has reached such a stage of perfection that any reliable heating engineer can install an effective system of steam heating. In this matter, however, as in the matter of ventilation, school authorities ought not to accept and rely upon the representation of business firms engaged in furnishing heating apparatus, but should rely upon the best expert advice uninterested commercially in the matter.

Defects of hot air systems — The difficulty with hot air systems is that they too often deliver air that is overheated and so deficient in water-vapor as to be positively injurious to the health of school children. Furthermore, when there is a strong wind accompanied by low temperature, the rooms cannot be equally

warmed by this method in buildings of considerable size.

Direct and indirect heating — The distinction made between direct and indirect heating is that in indirect heating the steam or hot water pipes are encased, and the heat radiated from them is conducted by flues to the various rooms. Indirect heating is often used as a part of the gravity system of ventilating, and in buildings in villages where ventilation by fan is too expensive, it affords, to some extent, a means of ventilating. The direct system of heating is that of placing radiators in the rooms. It is safe to say that no school building should be heated by direct radiation alone, unless an inlet that can be opened and closed passes through the walls of the building behind the radiator so as to admit air from the outside. Such heating is termed direct-indirect. Radiators are made for heating in this manner and are constructed with a damper at the base so that the air entering the inlet through the side of the building passes over the heating surface on its way into the room. The amount of radiating surface required for direct-indirect heating is about one-fourth more than that for direct heating, whether the heat is imparted by steam or by hot water.

The radiating surface, if steam is employed, should be so arranged and connected by valves that one-third of the radiating surface may be used in the

mildest weather, two-thirds in colder weather, and the whole in the severest weather. With a hot water system of heating, the degree of radiation is controlled by so regulating the fire that the water circulating through the system is of a temperature just high enough to impart the amount of heat needed.

An outlet flue for impure air, under conditions of direct or of direct-indirect heating, should be provided, and in order to make this flue effective it must be heated in some manner. The heat in this flue will need to be of as high temperature as possible if any withdrawal of impure air from the schoolroom, that may be regarded as even passable ventilation, is to be effected. In mild weather, it will be seen, therefore, that if the flue is heated with a hot water radiator, there will be but little withdrawal of the impure air from the schoolrooms. A stove in which a hot fire is kept burning has been effectively used in such flues. If a steam pipe is used, then the most efficient results will ensue, according to the inspectors of heating and ventilating of schools in Massachusetts, if the steam pipe is placed about a foot above the opening of the flue. The opening of the flue is to be in the lower part of the room, as explained on page 83.

Ventilation — Our present knowledge of the means of securing proper ventilation has been a matter of slow growth. It is the outcome of an incredible ex-

penditure of thought and money, and its development is marked by a long list of failures as well as partial successes. As is true in every other sphere of advancement, the failures have in reality been helps in securing the advance. Since the broad appreciation of the fact that the ill health and mortality of soldiers in barracks were markedly lessened by the employment of a crude means of ventilation, investigation has succeeded investigation with the end in view of determining what it is about vitiated air which produces the injurious results attendant upon continued breathing of it. One theory after another has been projected, to be at a later time abandoned. Investigations are still being conducted with the end just mentioned in view.

Vitiation of air due to organic matter — It will perhaps prove more satisfactory in discussing the necessity for school ventilation, if we state at the start the theory that has been until recently generally accepted, since it was during the period of the acceptance of this theory that the greatest advances in the means of ventilation were made.

According to this theory the dangerous effects of expired air are due to the presence of organic matter which is thrown off by the lungs and skin. This organic matter was supposed to be poisonous in its effects, producing the sense of oppression and discomfort felt by those who breathe the air of

rooms vitiated by the presence of many persons. The organic matter was believed to impart to such air an offensive odor, readily perceptible to one entering the vitiated air from out of doors.

It was further held that the organic impurities could be detected in various ways. Only two of these need here be mentioned. First, when a large amount of the vitiated air is drawn through water, the water gives forth an offensive odor due to the presence of organic matter, which soon decomposes. Second, when such air is drawn through strong sulphuric acid, it renders the acid brown.

Carbon dioxide an index of organic impurity — The amount of organic matter contained in expired air was never exactly determined, but the accompanying carbonic acid gas, CO_2, was taken as an index of the amount of organic impurities. Through chemical determinations of the percentage of CO_2 in the impure air of crowded rooms, and the consideration of these percentages with reference to the degree of odor which could be detected when passing into a vitiated atmosphere from outside air, some definite data were gained. These afforded a practical working basis, and very marked advances in ventilation resulted therefrom.

The conclusion was reached that the odor of organic matter thrown off by the continued breathing of the air in a room which was perfectly pure at the

start might be detected by the sense of smell when the CO_2 reached 7 parts in 10,000, and that the odor was very strong when the CO_2 reached 10 parts in 10,000. Seven parts of CO_2 was fixed upon as the amount of CO_2 permissible in air for healthy respiration. De Chaumont, in 1875, reported as the result of 473 analyses of air, that the odor of organic matter was on the average perceptible to the smell when the accompanying CO_2 resulting from respiratory or personal impurity reached 1.943 parts in 10,000; and that when it exceeded 9 parts in 10,000, or 9.05+ parts in 10,000, shades of difference could no longer be detected by the sense of smell.

Taking, then, 4 parts of CO_2 in 10,000 as the amount of CO_2 in pure outdoor air, it will be seen that according to the theory only 3 parts to 10,000 may be added from respiration before it becomes necessary to renew the air, or to provide some means of ventilation. Knowing approximately the amount of CO_2 thrown off by respiration each hour by a person, it was a problem of easy calculation to find the number of cubic feet of fresh air per hour necessary to each person in order to keep the amount of CO_2 down to 7 parts in 10,000. The standard established by law in Massachusetts for the ventilation of the school buildings, namely 30 cu. ft. per minute per pupil, or 1800 cu. ft. per hour, a standard which has been adopted by the business houses that

furnish ventilating plants for school buildings, is based upon this calculation.

Discredit of the theory of organic matter being deleterious — Recent investigations made by Haldane and Smith, and in this country by Dr. Bergey directed by Dr. Billings and Dr. Mitchell, seem to discredit the theory that it is organic matter in the air which is deleterious to persons who inhale it in "ordinary rooms." Should further investigations, which are certainly necessary to establish the fact that such organic matter in the air is not deleterious, confirm the conclusions of Dr. Bergey, it would in no way lessen the necessity of providing good ventilation in schools.

Facts cited which render ventilation necessary — Whatever further investigations may determine as to the nature of this organic matter, it is an unquestioned fact that persons in an improperly ventilated room are uncomfortable, and further, that persons in a well-ventilated room can perform mental and physical work without that feeling of discomfort, that sense of physical and mental fatigue, which are experienced by persons who work in vitiated air. It is a fact of common experience that when a number of persons breathe the air in a closed room, or a room in which there is very little renewal of the air, the air becomes oppressive and offensive. The term "crowd poison" has long been used by physiologists to characterize the quality of such air.

There are, moreover, certain other positive facts in regard to expired air which warrant the demand for a constant renewal of the air of schoolrooms. Expired air is saturated with moisture, and is breathed out at a temperature very nearly as high as that of the body. The air in a room where many persons sit rises, therefore, in temperature, and there is a rapid increase in the amount of moisture. This rise in temperature, resulting from the temperature of the expired air and the heat thrown off by the body, and the constant accumulation of water-vapor are two factors which produce discomfort and give the sense of oppression which many persons feel in vitiated air. The rise in temperature together with the excessive increase of water-vapor interferes, as has been pointed out by Dr. Billings, with the evaporation of moisture from the surfaces of the body. The greater the amount of moisture in the air, the more this evaporation is obstructed. When the evaporation is considerably retarded a rise of internal temperature succeeds, which disturbs and deranges the normal chemical changes taking place in the tissues. It is well known that cases of sunstroke occur in greatest number when there is a high per cent of humidity in the air combined with a high degree of heat. Instances have occurred where death has resulted from the crowding and confinement of steerage passengers below decks in a storm. The increase in heat, therefore, and in water-

vapor, renders the renewal of the air in rooms occupied by many persons necessary.

Pure outdoor air contains, per 100 volumes, 20.81 parts of oxygen, 79.15 of nitrogen (if we disregard argon and the other lately discovered constituents), .04 of carbonic acid gas, and a varying amount of water-vapor, depending upon climatic conditions.[1]

Investigations have shown that air expired by an adult man, when deprived of the water-vapor acquired, and reduced to the same temperature as when inspired, has 4.78 parts less of oxygen, and has gained 4.34 parts of CO_2, and .15 parts of nitrogen. In addition to these changes, the expired air is saturated with water-vapor, its temperature has been increased to within one or two degrees of the temperature of the body, its volume has been diminished from 2 to $2\frac{1}{2}$ per cent, and it contains some organic matter the exact amount of which has not yet been determined.

There are other considerations which render ventilation necessary. The skin excretes water, inorganic salts, and fatty acid. Some of these are absorbed by the clothing and very likely undergo decomposition, the products of which are a factor in the vitiation of air. Common experience attests the fact

[1] Pettenkofer of Munich, in 1858, employing a new method, found 4.5 parts of CO_2 in 10,000 volumes of air. In analyses of air made by chemists since his time, some have reported 3 parts, some as low as 2.6 parts in 10,000. Nevertheless, in all computation as to ventilation, 4 parts in 10,000 is taken for outdoor air.

that odors arise from any place in which soiled garments are confined for any length of time. The air, as Dr. Bergey has suggested, is further contaminated by the respiration of persons with decayed and unclean teeth, and of persons with disordered digestion.

Moreover, in schoolrooms a great amount of dust rises from the floor. These particles of dust float through the air, and to these particles bacteria cling. While all these bacteria are by no means injurious, it is probable that in an air conducive to the production of bacteria there are a greater number of injurious ones, such as those which produce diphtheria or tuberculosis, for it has been proved that a far less number of germs are found in well-ventilated rooms than in rooms where little heed is given to ventilation. The large use of crayon in our schoolrooms adds materially to the number of dust particles floating in the air.

Schoolroom air may be further vitiated from the gases rising from the heating apparatus, and also by the products given off from burning gas-jets. According to Dr. Billings, the burning of gas or oil, besides raising the temperature of the air and increasing its amount of water-vapor, vitiates the air by the addition of such products as carbon monoxide, carbonic acid gas, nitric and nitrous acids, compounds of ammonia and sulphur, marsh-gas, and particles of carbon.

Carbon monoxide, CO, is poisonous, combining with

the hæmoglobin of the blood, and displacing the oxygen. Sulphuretted hydrogen is also poisonous, and is destructive to the hæmoglobin. The burning gas also depletes the air of oxygen. A gas-jet burning 4 cu. ft. an hour consumes the oxygen from $21\frac{32}{100}$ cu. ft. of air. It will be seen, then, that, in addition to the oxygen of the air consumed, a large amount of fresh air must be added to dilute the impurities given off by a burning gas-jet.

Ventilation out of doors — These facts show sufficiently, we think, why ventilation is necessary. Let us, for the purpose of contrast, see what ventilation is out of doors. Dr. Billings is authority for the statement that in one hour with the temperature at 60° F., and when there is no perceptible wind, about 32,400 cu. ft. of air per hour will flow over and come in contact with the body of a man, supposing his body to present an area of 9 sq. ft. and the displacement of air to be at the rate of 1 ft. per second.

How often the air must be renewed — We have already mentioned the fact that the Massachusetts law requires 30 cu. ft. of pure air every minute per pupil, and that this amount has been generally adopted by the manufacturers of ventilating apparatus. There are some authorities that would require a greater number of cubic feet than this, but it is safe to state that in those schools where each pupil is furnished 30 cu. ft. of fresh air at the proper temperature, none of the effects are found

which are traceable to improper ventilation. Given, then, a standard schoolroom, 25 × 30, with ceiling 13 ft. high, and containing 40 pupils, the air would need to be changed once in about 8 minutes in order to furnish each pupil with 30 cu. ft. of fresh air per minute. With 48 pupils in the room, the air would need to be changed every 6.9 minutes. If we allow a change of air once every hour through the walls and about the windows, a change called natural ventilation, then the air would have to be renewed by the ventilating apparatus, for 40 pupils every 9.6 minutes, and for 48 pupils every 7.8 minutes.

Means of ventilation — There are two means of ventilation: first, ventilation by the moving of air due to the difference in specific gravity between heated air and cold air, usually spoken off as the gravity system; second, ventilation by mechanical means in which the fan is used. The gravity system of ventilation introduces hot air into the room through an inlet connected by flues with the furnace or with heated steam pipes encased so as to form an air chamber. The vitiated air flows out of the room through an outlet connected with a separate system of flues, the warm vitiated air rising because it is lighter than the outdoor air. More air can be moved by the gravity system of ventilation when the outside air is at an extremely low temperature, or, in other words, in very cold, still weather. Ventilation pro-

duced by the gravity system is unsatisfactory as a rule in winter weather, when the outside temperature is not low, and in spring and fall weather. The action of this system of ventilation is also interfered with by the pressure of high winds. The cost of putting in this system of ventilation is much less than the cost of putting in mechanical ventilation; but the cost in the consumption of coal to secure 30 cu. ft. of fresh air every minute for each pupil is largely in excess of the cost of securing this by the mechanical system. In most cases the gravity system fails to effect as frequent a change of air as is necessary to furnish each pupil with 30 cu. ft. of air per minute. Some gravity systems may attain this when conditions of weather are especially favorable; but in the experience of the writer, in his measurements of the results of gravity systems, it has been found that this system is unable to maintain under varying conditions the standard of ventilation.

The unsatisfactory results which have attended systems of ventilation by gravity have led to mechanical ventilation, or the use of the fan. There are two means of ventilation by the use of the fan: one called plenum or pressure ventilation, in which the air is forced into the building because of the pressure exerted by the fan; the other is known as the exhaust or vacuum plan, and is the reverse of the plenum, a fan being placed either at the top of the building or in

the basement and run so as to draw air out of the flues which connect with the various rooms of the building. In some schools a combination of the plenum and vacuum systems is used.

When the vacuum system is used alone it is generally found to be less satisfactory than forcing air into the rooms. The movement of vitiated air is not so easily controlled, because air is frequently drawn in through the openings around windows and doors, and an open window or door in one room disturbs the ventilation in other rooms, because the fan draws outside air through the open window or door more readily than it draws air from the rooms with doors and windows closed. The supply of air cannot be as well controlled with an exhaust fan as with a pressure fan. Cases have been known where the exhaust fan has drawn air through the plumbing of the building, and from accidental leaks from the sewerage of the building. With the pressure fan air is forced into the room, and the air in the room, being thus under greater atmospheric pressure than the outer air, is forced out through all cracks and openings, thus avoiding the dangers of the exhaust method, and insuring the required amount of pure air for each room.

Kinds of fans — In the plenum system, two kinds of fans are usually employed; first, the disk fan, which is simply an air propeller. This fan has the advantage

of moving large quantities of air when the resistance to be overcome is small. The pressure which disk fans exert without noisy vibration is, as a maximum, equal to about $\frac{1}{2}$ in. of water. The pressure of air is usually measured by its power to balance a column of water in a U-shaped tube, this pressure being expressed in inches of water. Wind pressure capable of sustaining a column of water 1 in. in height is called an inch of water pressure.

The second type of fan that may be used for plenum ventilation is the centrifugal or paddle-wheel fan. In these fans the air is forced centrifugally off the edge of the blade. They give air pressure between $\frac{1}{4}$ in. of water and 2 in. of water. One advantage of the centrifugal fan is that it can be run at a speed that will maintain these pressures with very little reverberating noise from the fan. The economical limit for these centrifugal fans can be placed at about 1 in. of water pressure. The aim in ventilating with fans should be to deliver large quantities of air at as slow velocity as possible, in order to obviate the vibrations of the air when it is carried through the ducts and openings in the system, a condition of noise which is disturbing to the school. If the air is delivered at a high pressure, with the prevalent plan of having one inlet in the room instead of effecting a distribution of the air by means of several inlets, the air enters at such a velocity as to produce a draft,

the air passing across the room and being reflected downward to the opposite side on pupils sitting there.

Much precaution must, therefore, be exercised that the ducts and shafts as well as the inlets shall be large, in order that air may be introduced at a comparatively low temperature and velocity, as small ducts and shafts require that air be introduced at a very high temperature and velocity. Air ought not to come into a standard schoolroom at a greater velocity than 6 ft. per second.

Even, however, with inlets and outlets large, and the introduction of the air at as low a velocity as 6 ft. per second, the plan of having one large inlet and one large outlet for a room is not in all respects hygienically good. Under such an arrangement, all the foul air is drawn to one part of the room, and pupils sitting near the outlet where the vitiated air constantly converges are supplied with air much worse than they would breathe were there no means of ventilation but the old-time manipulation of windows. Here is a serious defect in our present systems of ventilation. The introduction of fresh air should be distributed at several points along the side of the room each at the height stated below. Its introduction could, therefore, be at a very slow velocity. The vitiated air should be exhausted at several points along the side of the room, thus precluding its concentration at one point with its ill effects upon some pupils.

Place and size of inlets and outlets — An important matter in ventilation is the place of the inlets and outlets, and their size. Mr. Warren R. Briggs of Bridgeport, Conn., published in the third annual report of the Connecticut State Board of Health, 1879, the con-

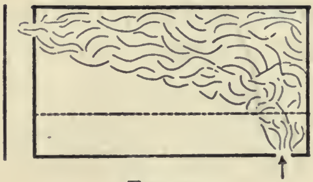


FIG. 20.

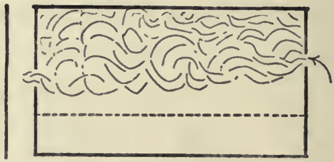


FIG. 21.

clusions from a series of experiments made by him with a model about one-sixth of the size of a standard schoolroom, in order to determine the most advantageous places for the location of the inlet for fresh air and the outlet for vitiated air. The system of ventilation used was the gravity system. He deter-

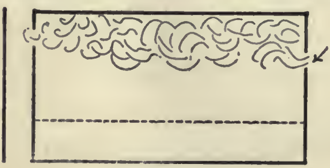


FIG. 22.

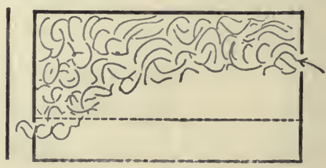


FIG. 23.

mined the movements of the air by the introduction of smoke with the stream of warm air, and was able in this way to detect the movements of the greater body of air which passed in and out of the model.

The movements of the air in six experiments are shown in Figs. 20, 21, 22, 23, 24, and 25, in which

the dotted line represents the position of the breathing line. The results of these experiments seemed so conclusive that the plan of placing the inlet eight or nine feet above the floor, and the outlet in the floor or within one foot of the floor, and both on the same side of the room, has been very widely adopted not only in buildings ventilated by the gravity system, but also in buildings in which the plenum system is used.

The Massachusetts Inspectors of Public Buildings, in their observation and investigation into ventilation,

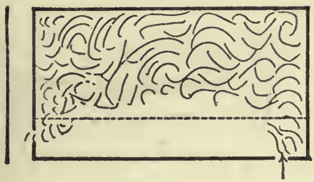


FIG. 24.

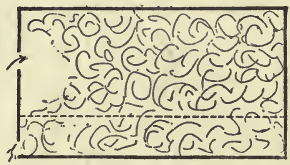


FIG. 25.

have reached some important conclusions in relation to the size of inlets and outlets and the position of these inlets and outlets with reference to the outside and inside walls of schoolrooms. The inlet should be as large as possible in order that air may enter at as low velocity as possible. The velocity of warm air entering the schoolroom should never be greater than 400 ft. per minute, and the inlet for a standard schoolroom ought not to have less than 4 sq. ft. of net area; while $4\frac{1}{2}$ and 5 sq. ft., it is said, will give better results. The inlet should be covered with a screen made of $\frac{1}{8}$ in. wire with $1\frac{1}{2}$ in. mesh, so that

the flow of the air will not be obstructed by the screen. With cast-iron registers the flow of the air, because of the design of the iron, is largely obstructed. The outlet of the standard schoolroom ought to have an area of not less than 4 sq. ft. The pressure of the air in the schoolroom should be a little in excess of the atmospheric pressure. It is the testimony of these inspectors that the best results seem to be obtained by a judicious combination of the plenum and exhaust methods. It will be seen that with a small fan for exhaust used in connection with a plenum fan, a closer adaptation can be made to the effects of high winds. The observations and experience of these inspectors show that in rooms with two sides exposed to the outer air, the inlet for the warm air and the outlet for the warm air should be as near the warm angles of the room as possible, and that in rooms with three sides exposed to the weather the inlet and outlet should be as near as practicable to the inner or warm side of the room, the inlet being at least 8 ft. above the floor and the outlet being, as has been stated, in the floor, or at least within 1 ft. of the floor.

Purity of air supply — The air supplied should not be drawn from the cellar of the building, nor from any locality where the air is likely to be contaminated. The supply of air should be drawn from a point as high above the ground as possible. In Scotland

some experiments have been made in washing and filtering the air. In some of the schools of Glasgow, a screen is placed just in front of the large plenum fans. This screen consists of a large wooden frame, across which hempen cords one-eighth of an inch in diameter, with an air space left between them of half an inch, are vertically stretched. When the fan is drawing air into the building, water is allowed to trickle from the top of the frame down over the hempen cords. The dirty appearance of the water as it flows away from the bottom of the screen is sufficient evidence of the dust and impurities taken out of the air in this manner.

At Dundee, Scotland, the air for the Chemical Laboratory of the University College is filtered before entering the building, by being passed through a jute cloth (light Hessian) which is stretched on frames 17 ft. by 4 ft. In using this screen it was found that the delivery of the air was increased nearly ten per cent, which was thought to be due to the fact that the jute screen prevented eddies. The cloth for these screens is furnished at slight cost, four cents per yard, and when used for this purpose, lasts about one year.

Mr. Alfred R. Wolff, of New York City, has used screens covered with cheese-cloth for filtering air. These have proved very efficient. The cheese-cloth is stretched on light wooden frames. Extra frames

are provided to replace those that become so covered with dust as to obstruct the flow of air to the fan.

Temperature of schoolroom air — The warm air delivered to schoolrooms usually enters at too high a temperature, and thus there is in general a tendency to overheating of schoolrooms. The air delivered should not be much above 100° F. A temperature of 68° F., and not to exceed 70° has generally been fixed upon as the proper temperature for schoolroom air. In measurements made by the writer, where buildings were heated by furnaces or by indirect radiation, that is, by air coming into the room from steam pipes encased at the bottom of the flue leading into the room, he has found on cold days the temperature of the entering air to be from 130° to 180°. Air heated very high while passing over the furnace is vitiated, because the dome of the furnace becomes hot enough to char the particles of dust in the air. There is also unquestionably sufficient ground for holding that the air coming in contact with the heated iron is vitiated by the production of gases caused by the oxygen of the air combining with the carbon of the heated iron dome and other parts of the furnace.

The temperature of schoolrooms usually too high — It may be said that schoolrooms, as a rule, are overheated. Dr. Lincoln is of the opinion that children can be made comfortable at 66° in a well-aired

room. Professor Burnham holds that a heated room should never be warmer than 66°. In England and Scotland the regulation is 65°. The writer has met many Scotch masters who hold that 56° is warm enough. Clement Dukes gives 55° to 60° as the proper temperature of schoolrooms. Every schoolroom should be furnished with three or four thermometers, and these should be hung near the breathing line. In some German buildings the thermometer is placed in the wall, and the janitor, by passing through the hall and looking through a glass window at the thermometer, is able to note the temperature of the air in the room.

If from any cause, as insufficient radiating surface, pressure of high winds, inadequacy of furnace to generate steam enough or to heat the water fast enough in a water system, the temperature of the room falls below 60° F., pupils should be immediately dismissed from the room.

Proper humidity — The proper temperature of a schoolroom cannot, however, be determined without taking into account the degree of moisture in the air. It is not sufficient that 30 cu. ft. of fresh air be furnished to each occupant of the schoolroom every minute. Good ventilation involves more than this. It involves the proper condition of the air delivered with respect to the amount of water-vapor it contains.

When the air contains all the moisture it will hold, it is said to be saturated, and the degree of humidity is 100 per cent. If the air contains one-fourth of the moisture it will hold, the percentage of humidity is 25 per cent. But the absolute amount of water-vapor the air will hold varies with the temperature of the air. This point will be dealt with a little farther on.

The writer has frequently, during the past few years, measured with the psychrometer the degree of humidity in the air of schoolrooms. In each instance a small amount of moisture in the air was registered. It was not uncommon to find the percentage of humidity as low as 30 per cent, and several instances were noted where pupils and teacher were breathing air that had only 20 per cent of humidity.

These low degrees of humidity of schoolroom air are confirmed by the measurements of others, and may safely be relied on as indicating the general condition of the air, in this particular, of schoolrooms during the season of the year when the air must be artificially heated.

If the humidity of the heated air of schoolrooms or of the living rooms of private houses, for that matter, is compared with the humidity of the outside air, it will be found that the relative humidity of out-of-door air is, as a rule, much higher. The loss

of humidity is, therefore, due to heat. Within ordinary ranges of temperature, an increase of 19° F. of heat, without the addition of more water-vapor, decreases by one-half the amount of water-vapor per given volume of air. In other words, if a given volume of air be taken at 30° of temperature and 90 per cent of humidity, and heated to 49° F., it contains per given volume only 45 per cent of humidity. If it be heated 19° more, or to a temperature of 68°, it contains per given volume only 22½ per cent of humidity.

We may state this another way. With an increase of 19° at ordinary temperatures, the capacity of air to absorb moisture is doubled.

As has been said, air will absorb moisture until it becomes saturated, or contains 100 per cent of moisture. This moisture it takes from any matter that will yield moisture. Its avidity for water-vapor is, it will be seen, the greater, the less the absolute amount of water-vapor the air contains. If air, therefore, when heated, is not supplied with a proper amount of moisture, it takes up moisture from every object that will yield it. The shrinking of the boards and beams of houses in winter, due to the absorption of moisture from them by the dry air, produces the cracks in floors, in corners, and around doors, generally to be seen after the rooms have been heated for a few weeks. Furniture, also, shrinks and gives way, due to the subtraction of the little moisture

that can be taken from the wood and from the glue which holds the joints. These effects are very evident to ordinary observation. But the effects of dry air upon the bodies of persons who are subjected to it are not so clearly observable. Nevertheless, they are just as positive. The artificially heated air, in which but a small percentage of moisture remains, absorbs moisture from the skin, the lining membrane of the nasal passages, the mouth, the throat, and the lungs.

There is excellent medical authority in support of the fact that heated dry air makes the skin dry and rough; it aggravates throat and catarrhal difficulties, and may even in some instances be the developing cause of such disorders. If the mucous membrane is constantly being deprived of its natural moisture, it is reasonable to hold that an unhealthful condition will at length result.

In an examination, five years ago, of a very expensive heating and ventilating apparatus that had been placed in a grammar school during the preceding summer vacation, the writer found the condition of the air at 10.15 in the morning as follows: temperature of room at breathing line 70° F., relative humidity, 25 per cent. There were 700 pupils in the building. These pupils passed through an air of 80 per cent humidity in going to school, breathed an air of 25 per cent humidity from 9 o'clock till 11.35, when they were sent out into an atmosphere having 80 per cent humidity. They returned at 1 o'clock to breathe the

same dry air till 3 o'clock, to be then dismissed again into a much more humid atmosphere. Such changes as these the pupils of many schools undergo repeatedly in the winter season. Such conditions are unquestionably a cause of colds and inflammation of the throat and bronchial passages.

Dr. Henry J. Barnes of Boston, who has recently given this subject investigation and very careful study, says, "The frequent failure of the vocal organs of public speakers and singers may also be the result of breathing excessively dry air."

The dry air of schools and dwellings has further an enervating effect. Dr. Barnes says that the relative humidity where the sirocco and the simoom prevail is never more than 10 per cent lower than is frequently observed in our own houses, and that the lassitude often felt in steam-heated apartments may partly be ascribed to such causes.

A slight movement of heated air possessing but a small degree of moisture is frequently felt as a draft, because the dry air when taking moisture rapidly from the skin has a tendency to lower its temperature, and therefore produces a chilly sensation. It is a matter of personal experience that we sometimes sit by a register where very warm but dry air is issuing, and have a sensation of coldness.

On the other hand, air that contains a high percentage of moisture seems to interfere with the normal heat pro-

cesses of the body. In summer, with the temperature at 75° or 80° and the humidity 90 per cent, we feel oppressed by the heat.

There lies a mean between these extremes. Dr. Barnes has aptly said that we sit out of doors in June in medium weight clothing when the temperature is 65° and a normal relative humidity of from 65 to 75 per cent.

In the opinion of sanitarians who have given this matter careful attention, a mean relative humidity of not less than 50 per cent is necessary for health. In reaching this opinion, they take into consideration the mean relative humidity of temperate climates. In England the mean is about 75 per cent. For Philadelphia it is about 69 per cent. Our schoolrooms, during the part of the year when artificial heat is necessary, are kept by regulation at a temperature of from 68° to 70° F., but without any care as to the amount of moisture the air contains. In view of the fact that a greater amount of heat is conveyed by moist air than by dry air of an equal temperature, it is safe to say that with 55 per cent of humidity the temperature of the schoolroom may be kept at 65° F. This temperature will be found, under the conditions stated, thoroughly comfortable as to warmth; its effect upon the health of pupils will be found to be strengthening rather than enervating, and a cause of colds and throat ailments will be removed.

Since it is necessary for health to add a proper amount of moisture to the air to replace that appar-

ently lost by heating, it becomes a question of how this may be feasibly done.

Hot air furnaces are provided with a waterpot. When this is kept filled with water, the evaporation therefrom renders the air less arid than without it, but because of the position usually given to the waterpot in the lower part of the furnace, it will evaporate only a small amount of the water necessary to be converted into vapor to maintain a mean relative humidity of at least 50 per cent.

Let us, for example, take outside air at a temperature of 25° F. and mean relative humidity of 65 per cent. This will represent favorable winter conditions. If the furnace supply 70 cu. ft. of air at 110° F. per minute, which may be taken as the capacity of an ordinary house furnace, it would require[1] 28.9 gallons of water in 15 hours, from 7 in the morning to 10 o'clock at night, the time during which the furnace is under the strongest fire, to render the humidity of the air 55 per cent with a temperature of 65°. The place usually given to the waterpot and the size do not permit of such evaporation.

[1] A cubic foot of air at 25° F. and 100 per cent of humidity contains 1.611 grains; at 65 per cent, $65 \times 1.611 = 1.04715$ grains. A cubic foot of air at 65° contains at 100 per cent of humidity 6.782 grains; at 55 per cent, 3.7301 grains. It would need, then, $3.7301 - 1.04715$ grains $=$ 2.6829 grains per cubic foot; 700 cu. ft. would need 1878.065 grains per minute; 15 hours $(60 \times 15 = 900)$, $900 \times 1878.065 = 1690258.5$ grains or 28.9 gallons.

But let us take a school furnace supplying fresh heated air for four rooms, each containing 48 pupils, and let us suppose the furnace to supply 20 cu. ft. less per minute for each pupil than the standard. There would have to be supplied, then, 192 × 10 cu. ft., or 1920 cu. ft. of air per minute. Assuming the conditions to be the same as in the previous illustration, very nearly 37 gallons of water would have to be evaporated into the air from 8 o'clock in the morning to 3 o'clock in the afternoon.

To secure the requisite amount of evaporation, then, the waterpot must be made larger and be placed in the upper part of the furnace. Some convenient or automatic device for filling is necessary.

Means employed to humidify the air of schoolrooms — In one of the recently erected schools at Yonkers, N. Y., Supt. Charles E. Gorton has devised for each of the large furnaces a copper pan in the form of an inverted frustum of a hollow square pyramid. The inverted base is very small and the sides flange out rapidly. The pan is filled by a pipe from the water supply, and a glass tube outside the furnace indicates the depth of the water in the pan. By increasing the depth, the evaporating surface of the water is rapidly increased and the supply of moisture regulated in this way. The pans are placed on the dome of the furnace and at the bottom of the

hot air flue passing from the fan over the furnace to the distributing ducts.

Porous earthenware vessels have sometimes been placed in the flues. They have, however, the disadvantage of obstructing the flow of fresh air.

Wet sponges hung so that the hot air in entering the room may pass through them are sometimes employed to increase the humidity. But these must either be often filled or kept wet by an automatic drip. In either case, this method of supplying moisture to air requires so much care and attention as to preclude its use.

In buildings heated by direct steam radiation, porous clay vessels may be placed upon the radiators, and these will be found to lessen considerably the excessive dryness of the air. These porous clay vessels may be procured of flower-pot makers, and are inexpensive. They can be made from a simple model or even from description, and should be long enough and wide enough to cover the entire top of the radiator. A depth of four inches is sufficient.

Some are of the opinion that if steam is let to escape noiselessly from the radiator, it will impart a sufficient amount of moisture. This is a mistake. Steam escaping in this way does not diffuse itself. The floor and woodwork about the escaping steam become covered with moisture. Indeed, a small area receives an excessive amount of moisture, but the

moisture is deposited instead of becoming generally diffused.

In buildings where the heating is effected by indirect radiation, or where it is partly indirect and partly direct, a very excellent method of humidifying the air has been devised by Mr. C. H. J. Woodbury of Boston. This method has since been tried in several schools, and with entire success. A small tube, connected with one of the steam pipes, is so arranged as to liberate steam into the cold air duct a few feet from the opening and at a considerable distance from the heating stack. The small tube is furnished with a valve, and the tube beyond the valve gradually expands in funnel form, in order to allow the steam to escape at a low velocity. The amount of steam escaping must be regulated to meet the conditions of external air. A deposit of moisture on the window pane of a room with coldest exposure has been found to be a practical way of determining when too much steam is escaping. A more exact way is by the use of the dry and wet bulb thermometer. This simple piece of apparatus is easily constructed. Two thermometers may be taken, care being exercised that they are graduated alike and record the same temperature under the same conditions. These may be tacked to a small flat piece of wood. Around the bulb of one thermometer tie a piece of linen cloth and let this project down from the bulb an inch. Fasten a small vial filled with water to

the piece of wood so that the linen cloth will dip well into it. Of course the bottle must henceforward be filled with water. The evaporation of the water from the linen about the bulb of the thermometer lowers its temperature according to well-known physical laws. The higher the temperature of the air, and the less moisture it contains, the faster is the evaporation from the wet bulb and the lower the temperature recorded. In order to maintain a relative humidity of 55 per cent, with room temperature from 65 to 68°, the reading of the wet bulb should be about ten degrees lower than the dry bulb. The escape of steam must, of course, be regulated so as to secure the proper degree of humidity.

The employment of the dry and wet bulb in this manner does not, however, give accurate results. If the thermometer with linen cloth about the bulb be fastened to a piece of wood, and the piece of wood so adapted mechanically that it may be rotated rapidly through the air, sufficiently accurate results may be obtained. Of course, the linen cloth must be thoroughly saturated with water before the rotation begins. The following table taken from Tables by Mr. Moore, Chief of the United States Weather Bureau, will show by inspection the degree of humidity of the air:—

Temperature of Dry Bulb	Degrees of Difference in Reading of Wet Bulb	Relative Humidity
65	8.5	59
	9.	56
	9.5	54
	10.	52
	10.5	50
66	8.5	59
	9.	57
	9.5	55
	10.	53
	10.5	51
67	8.5	60
	9.	58
	9.5	55
	10.	53
	10.5	51
68	8.5	60
	9.	58
	9.5	56
	10.	54
	10.5	52

In conclusion, it is to be said that care should be exercised in humidifying the air not to allow it to become too damp with moisture, as this condition is to be as much avoided, on grounds of health, as excessive dryness of the atmosphere.

How to measure ventilation — Many writers on school hygiene give descriptions of methods for ascertaining

by chemical means the amount of carbonic acid gas in the air of a schoolroom. The test with lime-water is misleading and inaccurate, and some of the other tests involve a nicety of manipulation which can be expected only of a trained chemist. There is little need, at the present time, of determining the amount of carbonic acid gas in schoolroom air, for when the capacity of the room is known, the number of pupils in it, and the amount of air coming in, the condition of the air in this particular may be calculated with sufficient exactness. What should be done is to measure by the use of an anemometer the number of cubic feet of fresh air entering the room and the amount of air leaving the room, and then determine the efficiency or the inefficiency of the ventilating apparatus by comparing the amount of air entering per pupil with the standard, 30 cu. ft. per minute.

To measure the air entering the room an anemometer must be used. Every school principal and every superintendent whose buildings are ventilated either by the gravity or mechanical system, should own an anemometer, and should take measurements at various intervals and determine the efficiency of the ventilation for the different rooms of the school buildings under his care. Facing p. 101, Fig. 26, a cut is shown of the best form of anemometer for this purpose. This instrument may be imported for schools, without duty, at a cost of $15.00. The revolution of the deli-

cate blades is recorded on the dial of the instrument. The instrument is so constructed that the recording mechanism may be stopped and started as the operator desires. The anemometer shows the velocity at which the air is moving through an opening. The velocity at which the air enters the room per minute, as indicated by the instrument, multiplied by the area in square feet of the opening, will give the number of cubic feet of air passing through each minute. In measuring the amount of air passing through a given opening, readings should be taken in the middle of the opening, near the bottom of the opening, and then at the top of the opening, and the average of these readings computed. It will usually be found that the air passes through the opening of the duct at unequal velocities, when the rate at the top and at the bottom are compared.

Ventilation of city and town school buildings — The most economical, and at the same time most efficient and reliable system of heating and ventilating, is that by which the requisite amount of pure air enters each room at approximately the desired temperature of the room, and by which, when weather conditions require it, the temperature of the room is maintained by coils or radiators placed along the exposed walls of the room under windows, these coils or radiators to be protected by a screen in order that the pupils sitting near them shall not be made uncomfortable by the

Fig. 5.

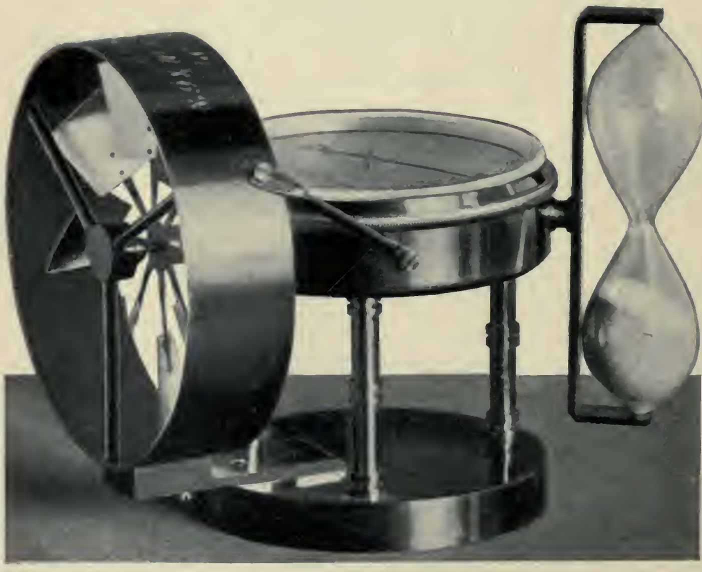


Fig. 26.

radiation. Separate and distinct systems for heating and ventilating are involved in this plan. The separation of these two systems permits the stoppage of the fan supplying the warm, fresh air, when school hours are over, and the heating of the building during the night and on days of no school, when severe conditions of weather make this necessary in order that the walls shall not become chilled, and that the class-rooms shall be at the proper temperature on the opening of the school in the morning. The radiators or coils should be controlled automatically by thermostats. Many cities and towns where electric power is available find it more economical to employ a low pressure system of heating, and to propel the ventilating fans by an electric motor.

Attention should be called to the disadvantages of a system often employed, in which the cold air taken from out of doors is drawn over the heating coils and then forced by the fan into the distributing ducts which branch off and lead to the various rooms.

The vertical hot air ducts which lead to the various rooms are connected separately at their base with a cold air flue, and dampers are so arranged that when the temperature of the room reaches 68° or 70°, the automatic thermostat closes the hot air damper and at the same time opens the cold air damper. Cold air is thus admitted to the room until the temperature of the room falls, when the thermostat closes the cold air

and opens the hot air damper. Under this system there is likely to be a failure in the proper distribution of heat when high winds prevail, and also during severely cold weather.

Under such conditions of weather it is necessary to run the fans a greater part of the time between the close of school at night and its opening in the morning, to prevent the walls from becoming so chilled that the building cannot be properly warmed during school hours. It will be seen that such a system involves not only a large consumption of coal, but also the cost of attendance at night. It will be evident that the warm air, as it leaves the heating coils, must be raised to a temperature considerably in excess of the temperature at which it enters the room, in order to provide for loss of heat in its transit through the ducts and also for leakage of cold air through the dampers. The air, furthermore, must enter the room at a considerably higher temperature than that at which the room is to be kept, as otherwise the room will cool below the proper temperature.

With such a system cold drafts and marked differences in the temperature of the air in some rooms frequently occur in cold weather. This condition may be caused in the following manner. Suppose the air as it passes the inlet to be 100° F. When the temperature of the room rises to 70°, at which the thermostat is set, the action of the thermostat

opens the cold air damper. The air which thereafter enters the room falls from 50° to 60° in temperature, depending upon outdoor conditions. The air at this temperature being heavier than the air in the room, falls after passing through the inlet, and is felt as a draft by the occupants of the room sitting on the opposite side from the inlet. As soon as the temperature of the room falls, the thermostat closes the cold air damper, and the inflow of heated air warms the room up to the temperature at which the thermostat opens the cold air damper again. In this way the temperature of the room successively falls and rises.

These serious disadvantages, as well as the increased cost of warming, may be avoided by the adoption of the plan already set forth of having radiators placed along the outer walls under the windows, using these to maintain the temperature of the room, and securing the ventilation by forcing into the room air at the temperature at which it is desired to keep the air of the room.

Cool air for city schools in summer — It is worth mentioning at this point, in view of the fact that many city schools hold vacation sessions, that if the fresh air flue leading from the fan to the distributing ducts can be carried underneath the cellar, the air driven through this flue in the summer time will be cooled several degrees. Of course, the flue should be so constructed as to be impervious to moisture from the ground as well as to ground air.

In the high school at Asbury Park, N. J., the plan of construction, due to some exigency, required that the main air flue leading from the fan at the front entrance of the building should be carried under the cellar some distance, whence it rose to be connected with the distributing flues. In a period of intense heat at the opening of school in September, it was found that by keeping the windows of the building closed and running the fan, which was propelled by electricity, teachers and pupils were thoroughly comfortable throughout the entire building. Measurement of the ventilation of this school proved it to be rather in excess of thirty cubic feet per minute for each pupil.

Ventilation of village schools — Although standard ventilation, 30 cu. ft. per minute for each pupil, cannot be secured under varying conditions of weather and wind without a fan and a motor or engine to drive the fan, the cost of such an equipment, together with the additional expense incurred for an attendant to run it, is such that village schools, as a rule, cannot afford this means of ventilation. While, then, standard ventilation is not possible, it becomes a question of the best ventilation that may be secured under the limitation of the appropriations voted. The removal of the impure air must therefore be effected by means of the draft produced in the outlet duct by warming in some way the air in the duct.

The most satisfactory plan, under ordinary condi-

tions, is to heat the air in the outlet ducts by steam pipes rising nearly the entire length of the duct and returning. Or the ducts may spring separately from a chamber of sufficient size encasing a large steam coil.

Such a plan of ventilating carries with it the supposition that the schoolrooms are heated by steam. For such heating and ventilating a combination of the direct and indirect systems will yield most satisfactory results. The indirect may be used to furnish a supply of fresh warmed air to the room, and the direct employed in severe weather to maintain the required temperature of the room.

Hot water systems of heating are often installed in village schools. While it is true that, under the conditions which obtain in these schools, hot water heating is more economical than steam heating, as the temperature of the radiating surfaces can be more evenly controlled than those of steam, yet in the case of village schools the means of heating ought not to be considered apart from the matter of ventilating. In mild and moderate weather, therefore, the lower temperature of hot water in the outlet ducts would not produce sufficient draft, and the outflow of vitiated air would be noticeably less than if steam were used.

If, however, a hot water system of heating must be installed more satisfactory ventilation can be secured

by heating the air in the ventilating flue by a stove, as stated on p. 68, than by hot water radiators.

In regard to the ducts, it may be said that these should rise from the room vertically, and that there should be a separate duct for each room. The ducts should be as smooth as possible on the inside to reduce the friction of the air to a minimum. The friction in brick flues greatly retards the flow of air. The ducts should therefore be made of tin or sheet iron.

Ventilation of rural schools — In order to ventilate the rural schoolhouse, the stove should be placed in one corner of the room and near the chimney. The stove should be enclosed by a sheet-iron jacket, leaving a distance of from 18 in. to 2 ft. between the stove and the inside of the jacket. The jacket should be about 6 ft. high, and should extend to the floor. The opening in the jacket for the purpose of supplying the stove with fuel should be as narrow as feasible. A cold air duct should be constructed to lead from the outside of the building underneath the floor, and to open beneath the stove, so that pure, fresh air will flow in, be warmed by the stove, and rise to the ceiling.

The point to be secured in the heating and ventilating of the rural schoolhouse is the quick and uniform distribution of the heat to all parts of the room. In the opposite side of the room from the stove, a tin or galvanized iron ventilating duct should

be constructed, oblong in shape, having its cross-section dimensions 12×6 in. The open end of this duct should be within 1 ft. of the floor. The flue should extend to the ceiling and run along the ceiling to the chimney. There should not be any sharp angle in this duct, but a curved bend where the upright section unites with that which runs along the ceiling. The ventilating duct should discharge into a large chimney flue at least 14 by 20 in. of cross-section area. In the middle of this flue there should run a sheet-iron pipe of sufficient capacity to deliver the smoke and gases from the stove. The heat radiated from this pipe when there is a brisk fire in the stove will cause a strong draft in the flue and draw the air out of the schoolroom through the ventilating duct.

The plan already described is the simplest and most economical for effecting some degree of ventilation in rural schoolhouses. A better plan would be to place the stove in one corner of the room surrounded by a sheet-iron jacket, and to construct a flue opening underneath the stove and connecting with the outer air, as has already been recommended. Three openings might then be made in the floor, one in the corner opposite that in which the stove is placed, and the other two on the sides of the room equally distant from the stove. These outlets through the floor, which are to be fitted with registers, should

have tin ducts running from them and uniting into one duct just before opening into the ventilating flue, which is to be constructed as already described. This would secure a more even withdrawal of the vitiated air from the schoolroom, and at the same time a more equal distribution of heat than by the employment of a single duct.

Ventilation by the use of windows — Something should be said in relation to what may be done in school buildings in which there is no provision for adequate ventilation. In this case windows must be used. The well-known device of placing a board between the sashes may be employed, but the pressure and direction of the wind are so variable and the changes in temperature so fluctuating, that the admission of fresh air in this way requires great attention on the part of the teacher, and the closest study of the varying factors already referred to. Children ought not to be required to sit in a draft or where cold air is pouring down upon the head and shoulders. Only a small amount of air in cold weather can be admitted through any device of window ventilation without exposure of some of the children in the room. As much relief as possible, however, from the vitiation of the air should be secured by a very judicious arrangement of window sashes. Relief may be found by opening windows and giving the pupils exercise while the windows are open, or by allowing them to

file out into the hall when the room is being ventilated. In ventilating the room by throwing open the windows, care must be taken not to cool the air below the dew point. At the end of every hour time should be taken for opening the windows and flushing, with proper precautions, the room with fresh air. The time consumed in this way will be found to yield gains in other ways, for pupils in a vitiated air are unable to put forth as much mental effort as they would under conditions of good ventilation. Lassitude is frequently the result of breathing vitiated air.

CHAPTER V

Sanitation

Warming and ventilation, under strict classification, are matters of sanitation, and their treatment might be expected in a chapter on sanitation. For the purpose, however, of presenting these in a different relation, they have been treated in a preceding chapter, while the other matters of sanitation have been reserved for this.

Latrines or closets — Some writers upon school architecture insist that these shall not be placed in the basement, but outside the building, and connected with the building by a narrow covered passageway. This recommendation need not be regarded in cities and towns having a good system of water supply and proper sewerage. Under the latter conditions the closets or latrines may be placed in the basement, providing they are constructed in a thoroughly approved way. In the first place, they should be well ventilated, and the system of ventilation of the latrines should have no connection with the system of ventilation of the school, to avoid all possibility of back draughts, and the mixing, under certain conditions, of

air from the latrines with the air of some of the schoolrooms. The latrines, therefore, should have a separate system of ventilation. The range system of latrines, adjusted to flush at intervals, will be found most satisfactory. If closets are adopted, they should be fitted up with the most durable apparatus and, at the same time, the most simple in action, so that they will stand the wear and unintelligent use of pupils without constantly getting out of order. They should act powerfully and automatically.

The floor of the latrines or closets should be asphalted, so that it can be thoroughly cleaned by washing, and it should be scrubbed at least once a week. Regular inspection by the principal of the school is vital in these matters.

The closets should be well lighted. A mistake often made is in putting them in dark places. A dim and insufficient light in closets is to a large extent the cause of the offensive conditions into which they so often fall. No deodorizers should be used in the closets, as they are merely palliative, and are frequently trusted to the neglect of cleanliness. What is further, when deodorizers are used, one is unable by the sense of smell to detect conditions which would otherwise be discovered and remedied. Well-constructed closets or latrines with the best plumbing and apparatus, thoroughly cleaned once a week, are the only satisfactory and permissible conditions in buildings where

a water supply may be obtained. One closet should be allowed for every twenty-five boys and one for every fifteen girls. Near every closet or system of closets there should be a sufficient number of wash bowls, with a proper supply of soap and towels, to provide pupils an opportunity to wash their hands after visiting the closets. The school should in some way beget in pupils the habit of doing this.

Urinals — The construction and care of urinals in schools are often unsanitary and offensive in the highest degree, and noticeably inferior to the other equipment of the school. Absorbent and corrosive materials are utterly unfit to be used in their construction. Wood, cement, and certain metals are therefore debarred. The most suitable and, in the end, the most economical materials are slate and hard asphalt. The slate should form the upright surfaces. A gutter of some impervious material at the base of the slate uprights is best, this to be connected with the sewer by soil-pipe adequately trapped.

The floor should slope slightly down to the gutter. Asphalt will be found most satisfactory for the floor. The surfaces exposed may be oiled, or running water may be used. Constant attention must be paid to the urinals to keep them in proper sanitary condition. One urinal should be allowed for every fifteen boys.

In buildings which do not have a water supply, the construction and care of closets becomes a much more

difficult and troublesome matter. Under such conditions, they should unquestionably stand apart from the building, and be connected with it by covered passageways.

Dry closets — For schools in towns and villages having no available water supply from mains, a dry system of latrines is much in use. There are several forms of these in the market, which differ more or less in some particulars, but which are alike in the general principle involved, namely, the passing of warm air through the vaults and thence up a ventilating flue, thus drying the excreta and carrying off all odors. The excreta after it is thoroughly dry is either burned by saturating it with kerosene, or disposed of in some other way. Whatever patented form of dry closet is used, there is one thing that must not be tolerated, namely, any connection between the ventilating system of the schoolrooms and that of the dry closets. The warm air which is passed through the vaults must in no case be the vitiated air drawn from the schoolrooms. An entirely separate supply must be provided for the closets to insure perfect safety against back drafts at any time.

Outhouses for country schools — There are a great number of schools where no other provision of closets than the ordinary outhouses is possible. Most country schools are unable to make any other provision than this. Unless constant vigilance is exercised on

the part of the teacher or on the part of the school authorities, outhouses become not only places of physical filth, uncleanliness, and offensive odors, but also sources of moral contamination. During recent years the Departments of Public Instruction in many states have given careful attention to the best means permissible under the conditions as to the construction and the taking care of outhouses. There is nothing better to be offered than the recommendations made by some of the State Departments of Public Instruction. These recommendations we here insert.

There should be separate outhouses for each sex, each house situated from 40 to 50 ft. from the school building, properly hidden and protected by lattice work and evergreens. A board fence 6 ft. high extending from the rear of the school building should separate the outhouses. The entrances to the houses should be facing the board fence. It is a mistake to place the outhouses in the extreme corners of the school lot or at a considerable distance from the schoolhouse, because the exposure in cold and inclement weather deters visitation, and as a consequence weakness and disease are engendered. These buildings should be thoroughly constructed, well lighted by windows, the sills of which are 7 ft. above the floor. The important feature of the outhouse is the vault. This should be built strongly of brick or stone, and plastered with cement on the inside to the top and over the top of

the masonry. All corners and dihedral angles of the vault should be rounded by filling in with brick or stone of the proper form, so that the interior of the vault when plastered with cement will be concave where sides and bottom meet. After the cement is dry it should be covered thoroughly with one or two coats of coal tar to protect it against the action of the weather, to render it non-absorbent, and to insure against any contamination of the water supply by percolation of drainage from the vault into the well.

The vault should be so constructed that its interior is easily got at. A tight wooden box or bin should be built near each outhouse to hold the dry earth which is to be used to keep the vault in proper condition. This earth should be thoroughly dry, and should be screened so as to remove all pebbles. Field loam is best for this purpose. Ashes may be used, but sand is not suitable. The loam, however, must be pulverized and must be perfectly dry to be efficacious. Every school day a sufficient amount of the dry, pulverized loam should be sprinkled over the contents of the vault to absorb completely all liquids. This is indispensable to rendering the contents of the vault inoffensive. The vaults should be thoroughly cleaned at least three times a year, and the interior well sprinkled with powdered lime.

Plumbing — It is unnecessary in this book to go

into the matter of plumbing. Sanitary plumbing is now well understood, and there are several special treatises which enter into very great details in relation to the subject. Unlike warming and ventilation, the plumbing of a school building does not differ essentially from that of any large building for public or residential purposes. No further word, therefore, need be said here than that the plumbing of a school building should be carefully planned according to the latest approved systems, and then intrusted to a thoroughly competent mechanic. Chandler says very strongly that plumbing should not be accepted without test, and that the only test which is satisfactory and convincing is that made by tightly closing the outlets on the roof and then applying pneumatic pressure to the entire system. He does not regard the peppermint or smoke test without pressure as sufficient.

Every year there should be a test of the plumbing to see whether there is any escape of sewer gas.

Water supply — In any community, the change from a supply of drinking water of inferior quality to a proper supply of pure drinking water is attended by a marked decrease of certain kinds of sickness and of certain diseases. In the school special care must be exercised in regard to the purity of drinking water. If the water supply is of questionable quality, then whatever can be done by filtration to render it

pure should be done. Other precautions must also be taken.

Drinking cups may become a means of communicating disease. Not only may diphtheria be communicated in this way, but the germs from decaying teeth may be carried by the rim of the drinking cup to the mouth of another pupil, and in this way sore mouth or tonsillitis may ensue. In schools having a water supply, the drinking cups should be so left after each usage that they are continually subjected to running water. Drinking fountains are recommended by some writers. These are constructed on the principle that a small and steady stream of water two or three inches in height issues from the orifice of an upright nozzle. The pupil drinks by placing his mouth at the top of the fountain-like stream. There is, therefore, by this means, no contamination spread from drinking cups. While, however, the drinking fountain obviates one danger, it invites another. At home the habit of looking at the water one is about to drink is inculcated in the child with the utmost care and solicitude. The immunity which such a habit insures is based upon thoroughly reasonable grounds, which a moment's reflection will disclose. On these grounds, therefore, drinking fountains of this kind are not to be recommended.

In schools which do not have a water supply, but where the water must be brought from a pump or

well, the water should under no conditions be kept in a pail. A large reservoir either in the form of a tank or a keg should be provided, and the water placed in this and then drawn from a faucet. The use of individual cups should be encouraged on the ground of safety to health.

The source of water supply in country schools must be thoroughly looked to. If it comes from springs, care must be taken that there is no polluting drainage that reaches the spring or stream. All wells should be thoroughly cleaned and drawn off or pumped out just before the opening of school after the summer vacation.

Daily cleaning of the school building — Any discussion of the daily cleaning of the schoolhouse would consider whether sufficient help is furnished by the school authorities to effect each day what is required to satisfy the demands of hygiene in regard to cleanliness. It is too often overlooked that for a great part of the year the janitor must sweep and dust the school building either by artificial light, or by the doubtful light at the close of the short days of the fall and winter. A great fault lies at the door of teachers in that they remain late in their rooms and are either oblivious to the fact, or entirely ignore it, that they are trespassing on the rights of the janitor in remaining so late in their class-rooms, and supposing that the janitor can busy himself about

other things. In the interests of thorough cleanliness some rule should be established by which the room should be ready for the janitor at a given time after the dismissal of school in the afternoon.

The schoolrooms, cloak-rooms, and corridors should be thoroughly swept at the close of every school day. Before sweeping, the windows should be thrown up, and the room well aired. The windows should be kept up, if possible, while the sweeping is going forward. Dust is inimical to health in many ways. We have pointed out that it is necessary to construct the building so as to avoid the collection of dust. It is highly necessary that the dust rising from the wear of the floor, the dust brought in from out of doors, bits of wool and cotton from clothing, worn-off cuticle, crayon dust, etc., should be as completely removed each day as it is possible to be. School buildings as a rule are not kept thoroughly clean. In the first place, not a sufficient amount is expended to keep them clean. Proper regard for health demands that if it can be effected in no other way, a curtailment of expenses be made in some other direction, in order that the building may be kept scrupulously clean. A scrupulously clean building reacts in its effect on the community, and engenders in the end a higher appreciation of the value and wholesomeness of cleanliness.

The floors should not be swept dry, but should be

sprinkled with wet sawdust and swept with a wet broom; crayon troughs should be brushed off and out, unless they are provided with the screened trough spoken of in Chap. I; the erasers should be thoroughly beaten. This may be accomplished by having an extra supply which can be taken from the room for a day at a time. After the room has been swept, and before the windows are closed, the desks and ledges should be thoroughly dusted. It will be found that after the windows are closed dust will settle during the night; in the morning, therefore, before school the desks should be wiped off with a damp cloth.

In the daily cleaning of the schoolroom, the gymnasium, if there is one, is concerned. This should be kept faultlessly clean, for here more than in any other part of the building dust is being continually stirred up and created because of the wear of the apparatus. In the exercises in the gymnasium a large amount of breathing through the mouth occurs, and if the room is dusty, the dust is carried down with the breath and penetrates further than in nose breathing. The entrance of germs in this way into the lungs is more easily effected. The floor should be swept in the same way as prescribed for the schoolroom floor, and the apparatus thoroughly dusted. Mats are a great source of dust in the gymnasium. These are usually covered with canvas, and through the excessive use to which the mats are subjected, the filling becomes ground into

fine particles which are forced through the canvas by the impacts upon the mats. They thus become frightful sources of dust in the gymnasium. Gymnasium mats should be covered with leather and the seams made dust tight. While the first cost is greater, yet it is made up in the end by the greater durability. Great labor and assiduity are requisite to keep the gymnasium clean.

Periodical cleaning of the school building — In addition to the daily cleaning of the school building, there are certain kinds of cleaning which need to be executed periodically. The blackboards, where these are of slate, should be washed once a week. The school building should be cleaned about a fortnight before the opening of school in the fall, thoroughly cleaned from attic to basement, every dark closet renovated, even to the remote parts of the basement, and all old material which has accumulated disposed of. In the fall cleaning, the floors should be scrubbed with hot water and soap, or soda. The walls, which hygiene requires shall be painted, should be thoroughly wiped, as well as all woodwork. The dust should be removed from all ledges and projections where it has accumulated.

The floors of the school building should also be scrubbed during the holiday vacation and again during the Easter recess, and at the same time the painted walls should be wiped off as high as the pupils can reach.

Dustless floor oils — Some school authorities, after the floor has been washed, apply a coating of oil to the floor. Opinion, however, is at present divided as to the merits of dustless floor oils. The claim made for these oils is that the oil when applied to the floor penetrates the pores for a short distance below the surface, and when dust or dirt falls on the floor a small quantity of the oil is drawn up which unites with the dust or dirt, rendering it somewhat adhesive, and thereby preventing its being easily stirred up by the passing to and fro in the room, or being blown about by currents of air. Little dust, moreover, is stirred up when the floor is swept. This claim, we think, is fully justified. A dustless floor oil, when properly applied, holds dust and prevents to a great extent its being stirred up by the constant movement of pupils, and its rising in sweeping.

Against the use of dustless oil, however, it is held that on maple floors it leaves unsightly stains, and that it darkens pine floors, and therefore absorbs a great amount of light, thus diminishing the illumination of rooms insufficiently lighted. Furthermore, it renders the floor more or less slippery, and leaves here and there patches of floor gummy and grimy that convey to the eye the impression of filth. The odor arising from a floor treated with dustless oil is objectionable to many, and lastly, a loud and serious protest arises because it soils dress skirts.

It is to be said that in too many instances the oil is improperly applied, and that several of the disadvantages following its use arise from its improper application. The oil should be put on the floors several days before they are to be used. Very little oil should be applied to the floor, and this should be well spread with a brush. Owing to the porous quality of some parts of the flooring and the hardness of other parts, the oil will not be equally absorbed. It is the unabsorbed oil which soils skirts and renders patches of floor gummy. To remove the oil not absorbed, the floor should be sprinkled with sawdust the day after the oil has been applied, and this thoroughly rubbed about with the broom and swept up. The disposition of the sawdust after it is swept up may prove a matter of disastrous consequence unless proper caution is exercised, as spontaneons combustion is likely to occur in such a mixture. To remove, therefore, all cause of danger, the sawdust should be burned.

The cleaning of desks and seats — Desks and seats are accumulators of filth, not only from the soiled hands of certain pupils, but also from the dust combined with perspiration and oil from the hands of pupils who are cleanly. In the great number of schools the furniture receives no further treatment than varnishing every few years. The soiled parts of desks and seats are always manifest to the eye

even when varnished over. In some schools the desks are washed each year with soap and water. Such a practice, however, unless unusual care is taken, whitens the varnish and removes it in places.

A very satisfactory way of cleaning desks and seats is to rub them off with a cloth saturated with kerosene oil. In this way all filth may be quickly removed and no harm done to the varnish.

Desks and chairs should be cleaned in this way at the same time that the general cleaning of floors, walls, etc., is done, namely, before school opens in the fall, during the holiday vacation, and during the spring vacation.

Clean windows — Windows are to be kept bright. They will, of course, be cleaned at the three periodical cleanings mentioned, and should be cleaned as much oftener as is necessary to keep them perfectly clear. Windows not thoroughly clean decrease appreciably the illumination of the room.

The disinfection of pencils and books — The habit of putting lead pencils into the mouth to wet them is a very common one with school children. If pencils, therefore, are collected and distributed again, even though they are marked with the names or initials of individual pupils, there is danger of communication and spread of disease in this way. Individual pencils are to be preferred; but in schools where supplies are furnished care has, of course, to be exercised to

prevent waste, and hence pencils must be collected at the end of each day. One of two ways may be employed to prevent the communication of disease by pencils. First, each child's pencil may be marked. When collected he places his pencil upright in a piece of apparatus purchasable in school supply houses, by which his pencil stands apart from others. The Bulletin Pencil Holder made by C. W. Bardeen, Syracuse, N. Y., is an excellent form of such apparatus.

If there is not time for this method, and the pencils are collected indiscriminately, then they should be placed each night in a tightly closed receptacle and subjected to the vapor of commercial formalin, using 1 c.c. of formalin to 300 c.c. or less of air space. An exposure of only fifteen minutes under conditions just stated is sufficient for thorough disinfection, if circumstances are such as to render it necessary that the disinfection of pencils from the various rooms be accomplished at one time, as for instance during the time of sweeping at the end of the day.

Books also are a source of communicating disease, and these should be disinfected from time to time, especially when there is a possibility of contagion from them. They may be collected, put into a tight receptacle, and exposed to the vapor of commercial formalin over night, or if circumstances require it, for but fifteen minutes. It is well, if the receptacle is large enough, to place the books on end and spread them open. One

cubic centimeter of formalin is to be used for every 300 c.c. of air space. This proportion must be rigidly adhered to, so far as the limitation of the amount of air to 1 c.c. of formalin is involved. Books are not injured in any way by being thus subjected to formalin vapor. The operator should expose his face as little as possible to the rising vapor. No objectionable effects, however, would follow beyond a slight irritation of the nose and eyes.

This simple and thoroughly efficient method of disinfecting books was developed at the Laboratory of Hygiene of the University of Pennsylvania, in 1896, by Mr. Elmer G. Horton, at the suggestion of Dr. Billings, director of the laboratory at that time.

It may be added here that wraps may also be disinfected by using a twenty per cent solution of formalin.

The use of colored crayons — In recent years a practice has become very prevalent, especially in primary grades, of decorating blackboards with colored crayons. If these crayons are made by dipping the ordinary school crayon in aniline dyes, they are not more injurious perhaps than white crayon. Frequently, however, in order to get brilliancy of color, crayons are used that are colored with pigments containing arsenic or sulphite of mercury and other injurious pigments. The use of such crayon carries with it danger, and is in disregard of the health of pupils. The dust of the colored

crayons adheres to the erasers in common use at the blackboard, and in this way the particles become scattered so that the pupils inhale them while working at the board with white crayon. In rooms where pupils do not work at the blackboard the dust from the injurious pigment crayons would be scattered by the teacher in the erasing which is necessary in the teaching of reading, number, and other subjects.

CHAPTER VI

School Baths

The purpose of school baths — In recent years, school baths have been instituted, and this addition to school equipment is gradually gaining a larger adoption, not only in Europe where it started, but also in America. Two distinct aims are held in view in the provision which is made by school systems for bathing. The first aim is for physical exercise and health. When this is the aim a swimming-tank is provided. Facing p. 128, Fig. 27, is shown a photograph of a swimming-tank in Edinburgh. There is one similar to it in Govan, across the Clyde from Glasgow, Scotland. At the latter place the tank is 27×59 ft. long, $5\frac{1}{2}$ ft. in its deepest part, and shallowing to 3 ft. 2 in. The temperature of the water in this tank is kept at seventy degrees. Periods during school hours are assigned for the use of the swimming-tank by pupils of the school, and it is open on holidays and Saturdays after four o'clock to persons living in the neighborhood. The water in the tank is not changed frequently, but the surface of the water is skimmed off once or twice a week. The swimming-tank

FIG. 27.

FIG. 58.

FIG. 59.

requires of necessity shower baths in connection with it, pupils and all other persons being required to wash thoroughly with soap before entering the swimming-tank. Because of the coal consumed to keep the water warm in winter, a swimming-tank is a very expensive adjunct of school equipment.

In Brookline, Mass., a swimming-tank is used in connection with the high school, but is not provided by the school authorities.

The second aim in providing the school bath is to produce cleanliness and to teach cleanliness. The most satisfactory means to attain the second aim seems to be that of the shower-bath. In some schools a bath-tub is employed, but this cannot be used as economically in regard to time as the shower-bath. It must also be cleaned after each using. It will be understood, of course, that dressing rooms are necessary in connection with the baths.

In the *Volksschule für Knaben* in Giessen, Germany, accommodating eight hundred pupils, school baths are located in the basement, and consist of eight large zinc pans, 5 ft. in diameter and of convenient depth. Three pupils, during the bath, occupy each pan or tub. The pupils are allowed to be in the tub five minutes. Baths are given at the end of every recitation. In German schools there is an intermission of fifteen minutes at the end of each recitation, the recitation and the intermission generally consum-

ing an hour. The boys bathe in relays. Each pupil is allowed a bath twice a week, but bathing is not compulsory. The time devoted to recitation periods throughout the school is used by the attendant for getting the bath ready for the next relay of pupils.

The city of Berlin had in June, 1899, six schools in which facilities for bathing were fitted up. A bath is allowed each pupil once a week, the bath usually taking five minutes. No child is compelled to take a bath. The baths in the Berlin schools are shower baths. The temperature of the water as the shower begins is 36 R. (113° F.) and is gradually cooled down to 24 R. (86° F.).

The Higher Girls' School in Zurich, Switzerland, accommodating from six to eight hundred pupils, has twelve shower-baths, and a sufficient number of dressing rooms. As the building is heated by hot water the baths are easily tempered, without providing a separate boiler for heating the water.

A school providing school baths must also furnish an attendant to direct the children, call them out of the bath, and keep the baths in order.

School baths in this country — In Boston, school baths have been in use since 1898, in the new Paul Revere School building, situated at the North End of the city, and baths are to be provided in the new school building in Charlestown now under contract.

In the Paul Revere School, there are 800 boys and

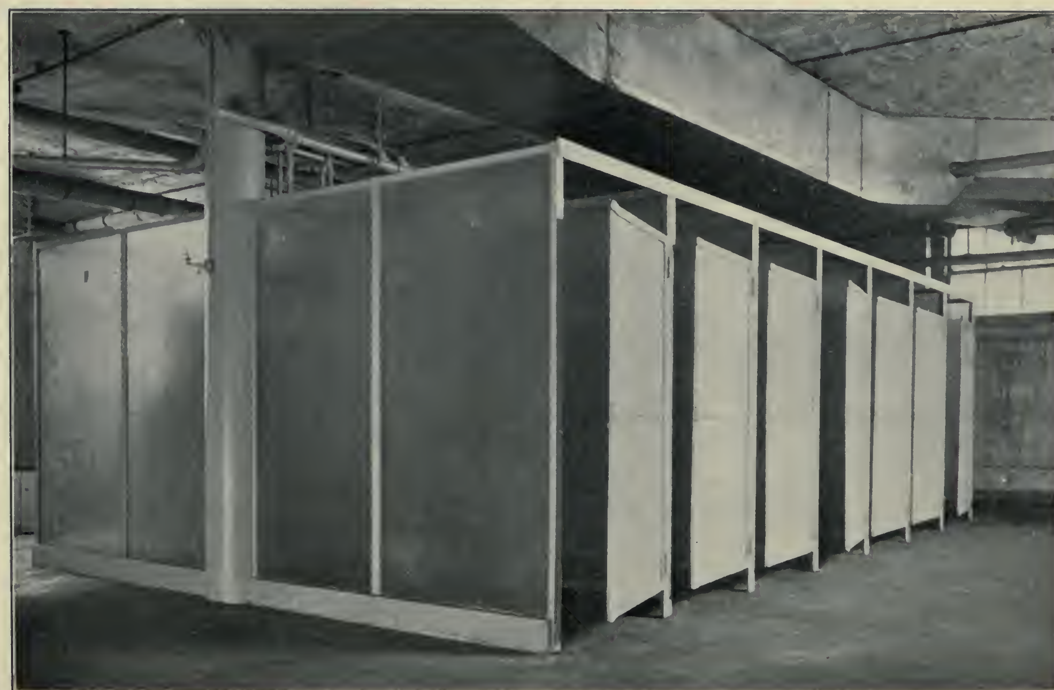


FIG. 30.

girls, and 125 pupils are bathed daily. The children bathe once a week during the entire school year. Bathing is not compulsory, but the opportunity to bathe is welcomed by ninety-nine per cent of the pupils. A period for bathing is allotted each class, the same as for a recitation. The time allowed for each pupil under the bath is three minutes. A matron has charge of the girls' baths, and a man looks after the boys.

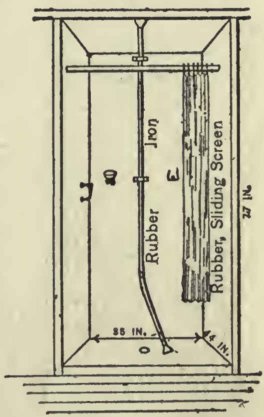


FIG. 28.

The baths are shower-baths, of which there are ten, with thirty dressing closets. An iron pipe extends down into the bath closet about 38 in. from the top. To the end of this pipe is attached a rubber tube with spray at the end, and reaching to the floor of the closet (see Fig. 28). Each child controls the shower as to the amount of water and its direction. But an attendant controls the temperature of the water, which is kept at 90°. The bath closets are made of marble and are each 77 in. high, 35 in. wide, and 44 in. deep, and fitted with a rubber sliding screen. The dressing closets, Fig. 29, are made of wood and differ slightly in dimensions from the bath closets, being $72\frac{1}{2}$ in. high, $29\frac{1}{2}$ in. wide, and 43 in. in depth. Soap and

towels are furnished. The average cost per bath is about $3\frac{1}{2}$ cents. Mr. Dutton, the principal of the school, reports that the baths are a great success morally and physically.

Public school No. 1, New York City, is provided with baths. They have just been completed. They are shower-baths, and are placed in the basement of the building, which has an asphalt floor. Facing p. 131, Fig. 30, a photograph of these baths is shown. There are fourteen of the bath closets with dressing closets contiguous, the separation between the two being made by a sliding rubber screen, so that by sliding the screen the pupil steps from the dressing closet into the bath closet. Fig. 31, facing p. 132, gives a view of the interior of the bath and dressing closets, the sliding rubber screen not being in place. Each of the closets is 38 in. wide, by 6 ft. 4 in. deep and 7 ft. in height. The frames are made of iron and the sides are of wired glass extending down to within 6 in. of the floor. The temperature of the room in which the baths are situated is kept at 80° F. in the winter. A special boiler is provided to heat the water for the baths.

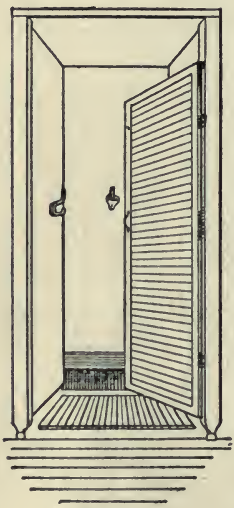


FIG. 29.

FIG. 31.

The boiler has a capacity of 530 gals. of water, and this amount of water can be heated to 212° F. in forty minutes. Dr. Ettinger, principal of the school, has, as yet, not had sufficient time for observation to report upon the results following the adoption of the baths as a part of school routine.

The school baths established and projected in this country are for the purpose of educating certain portions of the community in bodily cleanliness. That there is need of such education in certain parts of our cities cannot be denied. In crowded quarters, under the pressure of hard conditions and surroundings, personal cleanliness gradually becomes neglected, habits of uncleanliness are formed, and moral deterioration surely follows. The testimony of those who, under the conditions mentioned above, have instituted school baths is strong with reference to the physical and moral results arising therefrom. A child, it is found, has much more respect for himself when clean, and is much more responsive to law and order, and a positive moral influence is exerted upon the parents and homes of children. For one thing it shows itself in cleaner clothing for the child. It counteracts the unwholesome personal habits engendered in such homes, for the habit of bathing and cleanliness formed by the child from regular weekly baths from the age of six to fourteen will continue with him through life.

The writer found in one of the newer schools of

Chicago a commendable plan adopted in relation to provision for cleanliness, in cases when this was rendered necessary. A porcelain-lined tub and also a wash-bowl with hot and cold water were fitted up in a small room. Soap and towels were at hand. Pupils who came to school unclean were sent to the principal, and the principal sent for the parent, usually the mother, and talked with her of the child's condition, explaining to her what was necessary, and then asked her to use the facilities provided in the wash-room, and render the pupil fit to take his place in the class and go on with his work. The principal was able to effect this without in any way giving offence, a most necessary qualification. This plan in its effect upon the district had proved, it is claimed, most salutary. It gave the parents an object-lesson in cleanliness; it heightened their appreciation of its necessity; and in the best way the school reacted upon the homes of a certain part of the population without taking the duties which belong to the home upon itself.

CHAPTER VII

School Furniture

The school desk and chair — The most important articles of school furniture, considered from the point of view of hygiene, are desks and desk chairs, for the reason that the pupil spends during school hours so much time in work at his desk. Unless, therefore, desks and chairs are constructed with full regard for certain now well-assured laws of hygiene, they produce defects of eyesight, injurious effects as to posture, and wrong habits of carriage, which are borne through life, and sadly enough become more pronounced as the years of life increase.

Although in America the school desk and chair have for a long time been well and strongly made, occupying a minimum amount of space, and, from a purely mechanical point of view, quite satisfactory, yet the desks and chairs used in the greater number of our schools are constructed with but the slightest regard for hygienic principles.

This condition is largely due to the fact that the general form and kind of desk now so widely used obtained its hold more than a generation and a half

ago, before scientific investigations and experiments had been instituted in order to determine what the hygienic requirements are for school chairs and desks. The desks and seats now so widely in use force children into postures which bend the spine to the left; they cause the head to droop forward, contracting the chest and cramping the viscera; and by the time half the child's school years have passed, the position and shape of the bones have been altered.

In order to understand what a proper school desk and chair should be, it is necessary to consider certain physiological facts and laws and their bearing upon the matter.

The first of these to be considered is the relative height of pupils of school age, and the inequalities of growth during the school period.

Variation in height of pupils of same age — Professor Bowditch of Harvard University, in a most careful investigation and measurement of the height and weight of nearly twenty-five thousand school boys and girls of Boston, found certain surprising variations. Other investigations of a like character, made not only in America but also in Europe, agree in general with the conclusions of Professor Bowditch.

Let us take six years of age as the age of entrance at school. In many states the legal age is five years. According to Professor Bowditch's measurements of school boys six years of age on their last birthdays,

the heights varied from 40.66 in. to 47.13 in., making a difference of 6.47 in. The heights of school girls six years of age on their last birthdays varied from 40.57 in. to 47.36 in., a difference of 6.79 in. The same investigation shows that at eleven years of age on their last birthday, the height of school boys varies from 49.47 in. to 57.50 in., a difference of 8.03 in. With school girls of the same age, the heights ranged from 49.33 in. to 57.96 in., a difference of 8.63 in.

At fifteen years of age, the range of height in boys was from 56.55 in. to 67.90 in., the difference being 11.35 in. With girls of the same age, the range was from 57.39 in. to 65.00 in., the difference being 7.61 in.

The variations in height for each year of age not already given would show just as surprising differences. It is plainly necessary, then, that some provision in regard to the sizes of desks and chairs should be made to meet these variations.

Variations in growth — Besides the variations in height there is the matter of variation in growth, and for this provision must also be made in the construction of a proper desk and chair.

The growth of girls is most rapid from twelve to fourteen years of age, while from fourteen to sixteen the growth of boys is most rapid. The most rapid growth, it will be seen, falls about two years later with boys than with girls. The annual growth dur-

ing the maximum period is often an inch more than the annual growth at other periods. Another variation in growth is that with large children the period of rapid growth comes earlier than with small children.

There exist, moreover, certain anatomical differences of proportion between boys and girls. The *sitting height* of girls is greater proportionately than their standing height, in comparison with boys.

The necessity of vertical adjustableness of desk and chair — These facts clearly show that desks and seats of uniform size, or even of two or three sizes, for pupils of the same school age, would force many pupils to sit in positions not only uncomfortable to them, but injurious to the body. These various factors of difference in height and growth can only be accommodated by desks and desk chairs the height of which may be easily changed. In other words, desks and chairs must have some mechanical contrivance which will admit of their being raised and lowered to accommodate the difference of size in pupils, and the rapidity in growth.

But desks and desk seats that may be adjusted so as to provide for differences of height and differences of growth in pupils would by no means constitute a proper desk and chair required by the demands of hygiene. The desk and seat must not favor shortsightedness, and it must not force a pupil into wrong postures as shown in Fig. 32, facing p. 138, that at

Fig. 32

length become deformities of carriage. The matter is of much greater importance than school men generally recognize. The desks now widely in use are, as a rule, instruments productive of deformities. Let it be remembered that the pupil is at school from five to six hours a day, for from eight to twelve years. This is the greater part of the most important period of his growth, a time when injurious conditions leave their deepest and most lasting results.

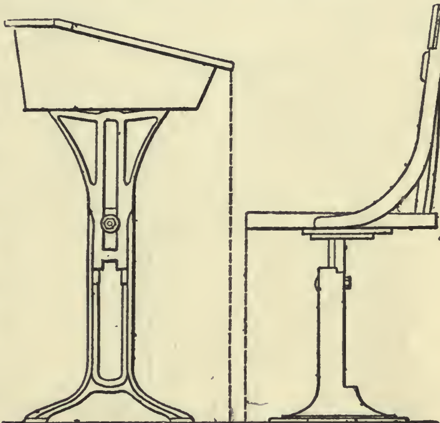


FIG. 33.

The desk and seat must favor proper posture—In order to set forth what further conditions a proper desk and seat must possess, it is necessary to discuss the factors involved in a proper posture of the body. When the pupil sits erect, with the pelvis resting equally on the seat, with the arms beside the hips, and with the head poised so as to bring the line of direction within a line joining the seat bones, namely, the bones of the pelvis which rest on the seat, the pupil is in a symmetrical posture, a posture which is the most economic of muscle energy, and a

posture, moreover, conducive to physical beauty and correct carriage. But the demands of school life do not permit the pupil to keep this posture. Reading, writing, ciphering, drawing, etc., are exercises to be performed at the desk. It is these exercises which, with improperly constructed desks and seats, lead to deforming postures and to short-sightedness. The desk and seat must, therefore, be of such a plan of construction and be so set as to enable the pupil to perform the exercises, or accomplish the work usually performed at the desk, with as little deviation from a symmetrical and easy posture as possible.

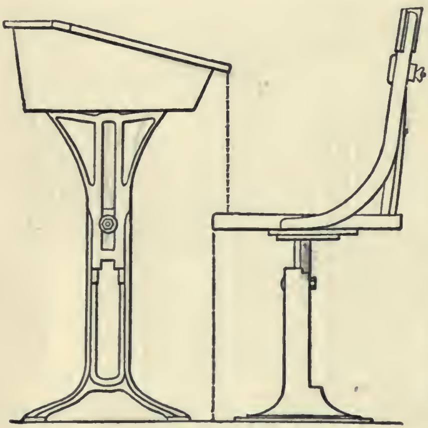


FIG. 34.

Fixed plus distance to be avoided.—If the desk and seat are set at what is termed a plus distance,[1] then

[1] Desk and seat are set at a plus distance when a vertical line dropped from the rear edge of the desk top and a vertical line dropped from the front edge of the seat to the floor leave a space between them not covered by desk top or seat. Fig. 33 illustrates plus distance.

Desk and seat are set at a minus distance when a vertical line dropped from the rear edge of the desk top would be in the rear of a vertical line

the body is thrown forward, the spine is curved backward and out, and the lungs, heart, and abdominal viscera are more or less cramped. Let the reader make a personal experiment by sitting at a desk the chair of which is set at a plus distance, or, what is practically the same thing, at a desk which is too low for him. If he observes closely the posture into which he falls as he works at the desk, he will realize the injury that is produced upon the growing child by the occupancy of such desks and chairs during his school life. The reader cannot fail to notice that the ribs are forced nearer together, restricting the expansion of the lungs and the action of the heart, and that the ventral surface of the body below the ribs is folded in, pushing the stomach out of place, cramping it, and consequently in-

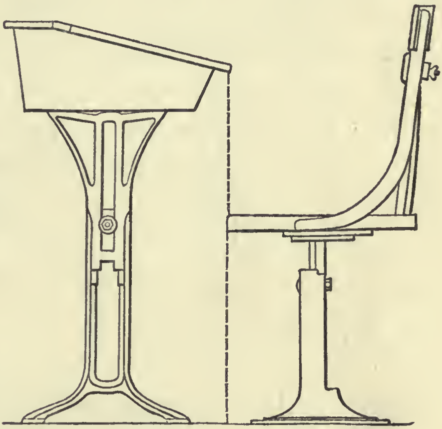


FIG. 35.

dropped from the front edge of the seat. Fig. 34 illustrates minus distance.

Desk and seat are set at a zero distance when a vertical line dropped from the rear edge of the desk top would coincide with a vertical line dropped from the front edge of the seat. Fig. 35 illustrates zero distance.

terfering with its functions. With such a posture, the muscles of the neck tire, and the head drops down, because the pull of gravity upon the head fatigues the muscles and overcomes the force which the muscles are capable of exerting to hold the head up. On the other hand, in the symmetrical posture spoken of above, the pull of gravity upon the head does not have to be counteracted by the muscles of the neck. When the head drops down in the forward leaning of the body caused by plus distance of desk and seat, the eyes are brought too near the book, and a condition productive of shortsightedness is imposed upon the pupil. It will be seen, then, that a fixed plus distance between seat and desk is to be avoided, and that the desk and seat must be set at a minus distance, so that the pupil may not be compelled to assume injurious postures which entail the serious results already stated.

The desk top must be adjustable for minus and plus distance — The minus distance at which a desk and seat are set, however, must be great enough so that the rear edge of the desk top may touch the ventral part of the body without pressing against it. This would bring the book or writing exercise near enough to the pupil so that he could sit in a symmetrical posture, or in other words a posture in which the line of direction would fall within the line joining the seat bones. But a fixed minus distance as great as this

FIG. 36.

FIG. 37.

would force the pupil at all times, whether reading a book at his desk, whether writing, drawing, or ciphering, to keep to a posture that would shortly become extremely tiresome because certain muscles are kept continuously in use, while many other muscles are almost wholly inactive. The desk and seat with so great a fixed minus distance would, moreover, impose a difficult, slow, and awkward movement upon the pupil in sitting down to his desk, and also in rising from his seat to take position in the aisle, when called upon to recite. It is evident, therefore, that the desk top should slide forward and back, or, in other words, be adjustable for large or small minus distances. It should also be adjustable for plus distances as well as for minus distances, as a small plus distance will give the pupil more freedom of movement while at his desk, and will also permit him to sit down at the desk and to rise from it with greater ease.

Proper slope of desk top necessary—Thus far we have shown the necessity, on hygienic grounds, for desks and desk chairs, or seats, adjustable as to height, and also for desk tops adjustable as to plus and minus distances. But still another feature is necessary in school desks to meet the requirements of hygiene. The desk top must have a proper slope. The height of a desk must be such that the pupil while writing may sit with his elbows not more

than a hand's breadth from the body. If a desk top has not sufficient slope, it will, when drawn back to make the requisite minus distance necessary in writing, be too high, and will thus throw the elbows out from the body and raise the shoulders. Such a position is tiresome and uncomfortable, and soon leads to a collapse of posture. If the adjustable top of the desk has an insufficient slope, say from five to eight degrees — the slope most commonly found in desks — the desk top when drawn back will be brought too near the eyes. Such a condition is greatly productive of myopia. Oculists agree in demanding that the book or writing paper should be distant from the eye at least 12 in., and they hold that when the book or paper comes nearer the eye than this, myopia is thereby favored. Other factors, however, than those already adduced, must be considered in reaching a conclusion as to what the amount of slope should be. It is well known that the line of sight, for the least tax upon the eyes, should fall upon the printed page perpendicular to its plane. With the head in good posture, the page of the book would need to be held at an angle of about sixty degrees from the horizontal and somewhat below the level of the eyes, for easy reading. It is a physiological fact that the eyes are naturally directed a little downward, because such action of the muscles of the eyes is not accompanied by fatigue as when

the eyes are directed upward, or even on a level, for any length of time.

But it seems impossible to construct a desk to meet such a condition with the other conditions necessary. Books must be placed upon the desk for reading, and writing exercises must be performed on the desk. It becomes a question, then, of the greatest slope possible consistent with the demands of certain practical requirements. Some writers upon school desks have gone so far as to recommend a slope of 45° for the desk top; others have recommended a slope of 30°. It is obvious that with so great a slope as either of these, ink would not flow easily from the point of the pen. And while slopes of 45° and 30° would unquestionably render the letters in reading but little foreshortened, and therefore less taxing upon the eyes, books, papers, and other articles could not be kept upon the desk, but would slide off with the least disturbance. Further than this, the great bend of the arm at the elbow necessitated by slopes of 45° and 30° would tend to constrict the muscles of the arm and render more difficult their easy coördination and free employment in writing exercises. After repeated experiments during the past five years, the author believes that the greatest slope permissible for the top of desks when all the conditions are taken into account is 15° — the slope recommended by the Vienna expert school desk

commission. Such a slope permits a perfect posture in vertical writing, and it may be remarked that with a lesser slope perfect posture cannot be maintained when writing the vertical script. Even with a slope of 15°, books and papers have quite a tendency to find the floor, and so it has been found necessary, to meet the needs of certain school exercises, to have the desk so constructed that the lid may be made to assume less slope than 15° — the slope for writing, ciphering, etc. — as is shown in Fig. 38, facing p. 146.

With a slope to the lid of 15°, with desk and seat adjustable as to height, and with the desk lid adjustable for as great a minus distance as 4 in., the desk and seat admit of such a complete hygienic arrangement that the pupil can easily maintain correct posture in writing. His shoulders will not be raised, nor will he be obliged to bend forward, and the writing will be the proper distance from the eye.

Attention was directed in the earlier part of this chapter to the differences in height of boys and girls of the same age, and to the differences in the rate of growth. It was pointed out that such factors as differences in height and growth could only be accommodated by desks and chairs the height of which might be easily changed. Having pointed out the hygienic requirements in relation to the school desk, and having given the reasons therefor, the require-

FIG. 38.

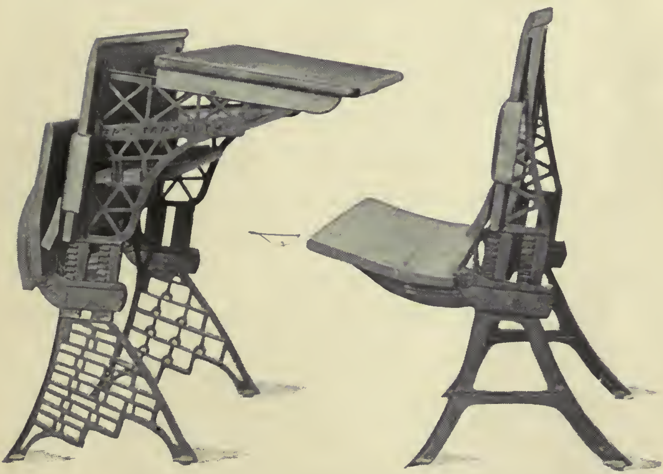


FIG. 39.

ments with reference to the desk seat or chair, and the reasons for them, must now be presented.

The desk chair or seat should be of such a height that the thigh of the pupil when seated will be perfectly level, the lower leg being in an exactly vertical position, with the foot resting wholly upon the floor. It will be seen, then, that the thigh and lower leg, when the chair is of the proper height, form a right angle with each other. To secure this position of the thigh for each pupil, the seat must be adjustable as to height. Its mechanism, as well as that of the desk, must be such that it can be adjusted to as small differences as a quarter of an inch over the whole range of its elevation or depression. Another factor is also involved in affording means for keeping the thigh in a level position. The bottom of the seat or chair cannot be flat, but must be somewhat concave, not exceeding in depth $\frac{3}{8}$ in. The lowest part of this concavity should be where the seat bones rest. The concavity should begin $1\frac{1}{2}$ in. back of the front edge of the seat. This concavity has also the additional advantage of counteracting the tendency to slide forward on the seat at the times when the pupil leans against the back of the chair. The concavity, however, must not be so deep as to throw the pelvis into an injurious oblique position when the pupil sits sidewise in his seat.

The chair should possess a back rest for support

when the pupil leans back to relieve and rest muscles that have become fatigued by other postures and exercise. This back rest should extend up high enough to support the lower parts of the shoulder-blades. It should not be straight or flat, but slightly concave toward the front.

The reader will recall the posture described as symmetrical and conducive to correct carriage. In this posture the line of direction coincides with the line joining the seat bones. But the arms are then suspended beside the hips. In exercises at the desk, the arms must necessarily be thrown out of this position. This, of course, shifts the line of direction, making it fall sometimes in front of the line joining the seat bones, and sometimes behind it, depending, of course, upon the position of the arms. It is evident that when the line of direction falls outside the line joining the seat bones, other parts of the body are brought into use to constitute a base of support for the body. When the line of direction falls in front of the seat bones' line, the other points of support involved are the thighs where they rest upon the front part of the seat of the chair. The seat of the chair must not, therefore, be too narrow, as this would render the chair tiresome to sit in. Moreover, a narrow seat permits the pupil to slide forward easily, because of the leverage which his trunk exerts against the back of the chair, thus leading to one of the worst and most deforming postures, namely, that in

which the body is supported by the lower end of the spine as this rests upon the chair seat, and by the shoulder-blades and spine where these press against the back of the chair. In this posture, a harmful pressure is brought upon the sacrum and coccyx. The seat of the chair, therefore, should be at least two-thirds as long as the thigh, and its front edge should be rounded to prevent pressure upon the nerves and blood vessels of the thigh at this point. The width of the seat is also of importance. A seat of much greater width than the two thighs offers constant temptations to bad postures. Chairs are therefore to be favored rather than seats attached to the desk.

Hip rest — Besides having the chair seat of the length just given, another feature has been recommended in order not only to prevent the pupil from assuming the deforming posture described in a preceding paragraph, but also to aid him in more easily maintaining a good posture. This feature is a hip rest.

The rest supports the small of the back and helps the pupil to maintain an upright posture with a small expenditure of energy. A simple experiment will convince the reader of the efficacy of a hip rest. If, when sitting in a fairly good posture and leaning against the back of the chair, an ordinary sized book is put between the chair and the small of the back, it will be found that a book so placed not only forces the body to take a more upright posture, but that it

supports the body in such a posture. From the emphasis that has been already placed on the difference in height of pupils of the same age, it is evident that the hip rest should be so constructed mechanically that it can be raised or lowered.

Foot rest — A bar near the floor and extending between the standards of the desk for a foot rest is sometimes attached to desks. The weight of opinion is now against foot rests. In the first place, they restrict the free movement of the pupil's feet while at his desk, interfering with his opportunity to shift his feet and legs for relief from inactivity. In the second place, foot rests prevent the thorough sweeping of the floor under the desks. These reasons are sufficient to condemn foot rests.

Single desks — Every school ought to be furnished with single desks and seats. No double desks, or desks at which four pupils may sit, should be permitted in this age, in any school. Single desks and seats are a check upon the spread of infectious diseases, they preclude the overcrowding of schoolrooms, they render the control of the school by the teacher much easier, and they insure the pupil his individual right to accomplish his tasks without interruption and distraction by a seatmate.

The Heusinger desk — There are now in the market several good desks and seats which admit of being adjusted vertically to meet the varying growth and

height of pupils. The principle of vertical adjustableness seems to be pretty thoroughly recognized. But the necessity for proper slope for writing, as well as for adjustableness for plus and minus distance — a matter equally as important as vertical adjustableness, — demands and should receive full recognition from manufacturers of desks. We are not concerned here with the commercial advantages or asserted merits of desks. The one condition on which we would judge any desk is, how fully it embodies the hygienic principles which have been shown to be indispensable for health, posture, and unimpairment of vision.

We insert here illustrations and the description of a desk and chair which up to the present time best embody, in our judgment, all the hygienic principles which have thus far been formulated for proper desks and chairs.

The illustrations facing p. 142 show the features of the Heusinger desk. The desk and chair are each adjustable vertically. The desk is constructed according to the box pattern, and the lid has a slope of 15°. When closed, as in Fig. 36, there is a distance of one inch between the front edge of the chair seat and the edge of the desk lid, technically known as plus distance, which affords the pupil greater ease in taking his seat or rising from it. Fig. 37 shows the desk lid drawn down to a minus distance of three inches, so that in writing or ciphering the pupil may maintain

an unharmful posture. In Fig. 38 another feature of the desk will be seen. By throwing up two short wooden standards fastened to the inner sides of the desk box, the desk lid is raised ten degrees, giving the lid a slope of five degrees, a necessity in certain kinds of desk work to prevent specimens or objects from being easily brushed off, as would be the case with a constant slope of the desk lid at 15°. In Fig. 40, facing p. 152, the adjustable hip rest will be noticed fastened to the upright rods of the chair back. The Heusinger desk has been under schoolroom test for the past four years, and its superior advantages fully proved. It is here described for the first time. The posture a pupil may maintain while writing when sitting at this desk is shown in Fig. 59, facing page 210.

The Ideal desk — This desk is worthy of notice here, because it is adjustable for minus and plus distance. The desk and seat are shown in Fig. 39, facing p. 146. The desk is not adjustable as to height. This, it must be said, is a defect, although a defect which might easily be overcome by a simple mechanical device. Ideal desks are made, however, of different sizes, and the seat is adjustable vertically. The mechanism of the seat is such that the pupil may himself adjust his seat to the proper height. The back of the seat, it will be noticed, has an easily adjustable hip rest. The slope of the desk is 10°. Its greatest advantage is the sliding

FIG. 41.

FIG. 40.

top. This permits of setting desk and seat at a plus distance, and when the sliding top is drawn down, a full minus distance is secured for writing and ciphering. The sliding top when pushed up is held in position, so that the ink well and books beneath are all covered.

Rules for adjusting desks and seats — the chair — The upper surface of the seat should be as high above the floor as the child's leg is long, measured from the sole of the foot to the underside of the thigh near the knee joint, when the thigh and lower leg are bent at right angles. A measuring rod is furnished by some makers of school furniture, as shown in Fig. 40, facing p. 152. It consists of a square rod on which there is a scale of inches. The square rod is fitted with a sliding arm, having two branches projecting at right angles on opposite sides of the rod, but with one branch of the arm below the other a distance equal to the thickness of the chair bottom. The pupil is seated with the foot pressing fully upon the floor and the lower leg vertical. The upper branch of the projecting arm is placed under the thigh near the knee joint, and this distance read off on the scale. The number of inches may then be written on a piece of paper and left on the desk fastened under the ink well cover for the janitor to adjust the chair to this height. The chair bottom may then be raised or lowered, and rested on the lower branch of the projecting arm as shown

in Fig. 40, and quickly secured by the nut on the chair standard.

The hip rest — The hip rest must be adjusted so that it supports the back just above the hips.

The desk — The top of the desk should be raised or lowered, as the case may demand, so that the pupil, in writing, will not have his shoulders raised in the least, nor be forced to drop the head and bend the spine forward. For desks adjustable for minus distance, the sliding top must be drawn down so that it nearly touches the ventral side of the body, when the pupil is sitting in correct posture after the chair has been properly adjusted. While in this position the desk should be raised or lowered, as may be required, so that the pupil's forearms will rest easily on the top, with the elbows a hand's breadth from the body and in proper position for writing with a desk slope of 15°. With this adjustment the pupil will be able to maintain an easy and correct posture. His shoulders will not be raised, nor will he be obliged to drop the head or bend the spine forward.

Periodical adjusting — The period of maximal growth in height of boys and girls extends from the end of March to the middle of August. The minimal period of growth in height follows the maximal period, and extends to the middle of November, a period of three and a half months. The middle period of growth in height follows the minimal period, and extends to the

end of March, a period of about four months. The ratios of the daily rate of growth for the maximal and middle periods to the minimal period are respectively two and a half and two to one. Giving heed to these facts, desks and seats should be adjusted vertically twice a year, at the opening of school in September and again in February or March. At whatever time during the year a pupil enters school or is transferred to another room, his seat and chair should be adjusted to him.

Neglect in adjusting desks — Instances are very common in which schools have been furnished with seats and desks adjustable vertically, and after adjustment one or two times the matter has been neglected, thereby subjecting the pupils to just as harmful conditions as if the desks were not adjustable. Makers of certain desks are to some extent responsible for this. The adjustment of the chair with its one standard is an easy matter, but it is a very tedious piece of work to adjust the desks of a school when considerable time must be spent by the teacher and the janitor with each pupil in getting the desk properly adjusted to him. The teacher, no matter how fully she appreciates the value of adjusting the desks, cannot be expected to do it, and furthermore, she is not competent mechanically. The desk has two standards, and the two standards are what give the difficulty, because the desk while one standard is being fastened is likely to sag to the opposite side. A piece of

apparatus might easily be constructed which could be placed between the standards of the desk, supporting the desk from the bottom. It could be so devised that, by the moving of a lever or the turning of a crank, the desk would be quickly raised or lowered. The desk at every point would be in horizontal position, and when the desk had reached the right height the standards could be easily fastened. Until some simple device of this kind is furnished, there will be neglect in adjusting desks. The same scale used for the seat could be used to measure the distance of the elbow from the floor when the pupil sits in correct posture in the seat which has been previously adjusted. This measurement could be left on the desk, and with the apparatus spoken of the janitor could quickly and easily adjust the desk to the required height.

CHAPTER VIII

Postures and Physical Exercises

Conditions productive of bodily deformities — The conclusions drawn from the physiological investigations made in Europe and America into the distortion of the body caused by the demands and permissive practices of school life are startling in the extreme. The longer period which children now spend in school, and the severer demands which an enlarged curriculum makes upon them, place upon school authorities and teachers a heavy responsibility. Every condition must be eliminated and every care exercised to prevent the acquiring of physical defects in school, as well as to prevent the accentuation of those physical defects which the child may have possessed before entering school. Improper chairs and desks at which pupils are obliged to sit, the wrong postures which they are allowed to take in standing as well as in sitting, and the muscular fatigue caused by the inactivity of a great number of the muscles of the body for a long period, — all these exist in surprising degree in a great majority of schools in this country, and they can be regarded in no other light than as causes greatly pro-

ductive of bodily deformities. What Dr. C. F. Scudder found in Boston, in 1892, still exists, a thousand times over, in our schools. In several rooms he discovered girls who differed seven years in age, and very nearly $22\frac{1}{2}$ in. in height, seated at desks and in seats of exactly the same size. In another instance he found 161 pupils, ranging between nine and seventeen years of age, and differing $17\frac{3}{4}$ in. in height, seated in seats and at desks of exactly the same size. In still another school he found 91 girls, differing in age five years and two months, and in height a little over a foot, seated in seats and desks of the same height. Eighteen per cent of this last number of pupils, when sitting back in their seats, could not touch the floor with their heels. He reported that twenty per cent of the girls of the grammar grades of Boston were decidedly round-shouldered as a result of malpositions due to defective desks and seats.

Postures in sitting — A posture which pupils fall into because of defective seats and desks, and also because of inactivity from long confinement, not only at defective desks and seats, but also at hygienic desks and seats, is shown in Figs. 41 and 42. In this posture the pupil has slipped forward in his seat, and is resting nearly the whole weight of the trunk on the end of the spine and on the shoulder-blades. It is held that the need of motion at the hip joint is an important factor in causing the pupil to assume this posture.

FIG. 42.

FIG. 43.

The injurious effects which result from such a posture must be evident to any one having an elementary knowledge of the structure of the human body. The dropping of the head downward, not only constricts the chest and tends to decrease the amount of air inspired, but it also stretches the muscles which connect the head with the spine, with the result that these muscles at length become elongated, and as a consequence not only does the pupil become round-shouldered, but there ensues a carriage in which the head is pitched forward. By such a posture the erect carriage of the body is further distorted in the reduction and change of the natural curves of the spine. Composed as the spinal column is of vertebræ and intervening cartilages, it possesses considerable mobility, and is, therefore, easily susceptible to the influence of gravity. The posture here spoken of, bringing some of the weight of the internal organs upon the spinal column, tends to produce in the spine a curve backward.

Another injurious posture is shown in Fig. 43, where the pupil is stooping over his desk. This posture, besides being a cause of myopia, contracts the chest, interferes with free respiration, and puts additional labor on the heart because it is constricted. For the reasons given in the preceding paragraph, it results in round shoulders, a curving of the spine backward, and a carriage in which the head is pitched forward. An-

other effect which follows such a posture is the displacement of the internal organs, not only of the abdomen, but also of the pelvis. A pupil is thrown into such a posture by a desk which is too low for him, and also by a desk and seat set at a plus distance.

The sitting posture most economical of muscle power, and at the same time most conducive to proper carriage of the body, has already been set forth on p. 139. This posture has been described by Dr. Eliza M. Mosher, whose contributions on the subject of habitual postures of school children are very clear and valuable. In this posture the pelvis rests equally on the chair, the spinal column is erect, the head is poised directly above the spinal column, and the arms are balanced on a line with the hips. This posture is the most economical of muscle force because there is no antagonism between the force which the muscles must exert to keep the body in this position, and the force exerted by gravity upon the head and the trunk. When, however, the head drops forward, then muscle power must be exerted against the force of gravity, a condition speedily resulting in fatigue of the muscles involved.

As has been explained in Chap. VII, desks and seats must be constructed upon hygienic principles, in order that the pupil shall be under no disadvantages conducing to bad postures in so far as desk and seat are in themselves concerned. But it is often found,

in schools which have adopted adjustable desks and seats, that postures are far from what they should be with the improved desks. The simple fact is that under such conditions pupils have been kept at their desks until they are fatigued and have not sufficient muscle power and control to maintain proper postures. This state of fatigue results from the inactivity of certain muscles and the protracted use of but a few. Let it be remembered that the best school desk becomes exceedingly tiresome to the pupil when but little opportunity is given during a school session for complete change and active readjustment of the various muscles, such change being an imperative physiological demand of the growing organism.

Periods of relief, and corrective exercises — In order, then, that the pupil may be in proper physical condition to maintain an erect posture while in his seat, and thus to form correct habits which he will carry through life, he must be given periods of relief from sitting at the desk, and corrective exercises at different times during the day. In the first year the child should not be confined at his desk more than one-third of the time. Short periods of occupation at the desk, with periods of activity twice as long out of his seat, should be the rule for the first year. These periods of activity may nearly all of them consist of some form of physical movement correlated with intellectual exercises. In the succeeding years of the elementary school the total

amount of time occupied at the desk may be gradually lengthened, but in addition to regular recesses there must be provided frequent short intervals of respite from sitting at the desk devoted mostly to some form of brisk physical exercise. In the last year of the elementary school course, besides the recesses and the passing to and from recitation, there should be four stated periods of three minutes each during the morning session and three during the afternoon session, devoted to physical exercises designed to bring into use muscles inactive at the desk and to counteract the tendencies to malposition.

Postures in standing — In Fig. 44, which is taken by permission from Dr. Mosher's study printed in the *Educational Review* of November, 1892, a posture is shown that Dr. Mosher deprecates very strongly. This is a posture frequently assumed in the schoolroom by boys and girls, but more frequently by girls. It is a posture no good teacher will tolerate. It will be seen by reference to the picture that in this posture the left hip is lowered and the left shoulder raised, elongating the left side of the trunk, and of course producing a bending of the spine to the left. In this posture the tendency is to drop the head to the right in order to bring the line of gravity nearer the right foot, thus putting the body in such a position that muscular force need not be exerted to overcome the force of gravity upon the extended parts. It will further be seen that the line connecting the hip


FIG. 44.


FIG. 45.


FIG. 46.

joints is in an oblique position. The intestines because of their mobility are, therefore, thrown over to the left side. Their weight, falling upon the pelvic organs, displaces them to the right. The injury to health and the disorders, especially in the case of girls, arising from such postures becoming habitual, entail suffering, deranged conditions, and seated sources of weakness, requiring in many cases surgical treatment. The faithful teacher will not allow pupils to assume such a posture.

Proper posture in standing — When the pupil stands with the heels so placed that neither of them is in advance of the other, and with the weight on both legs, we have a posture in which the trunk is evenly poised on its supports, the pelvis, and all the parts of the body are symmetrically placed. Such a posture is shown in Fig. 45, taken from Dr. Mosher's article to which reference has already been made. If in this posture, the weight is thrown slightly on the balls of the feet, the hips drawn back, the head poised a little back with the chin drawn in, the chest will be thrown forward, and we have correct posture for standing. It is the posture which the pupil should be trained to take while standing for short periods. Since, however, both legs undergo the same amount of muscular tension at the same time, it is a posture which the pupil will not keep if he is obliged to stand long. Muscular relief and change are necessary. If, then, in any lesson-exercise

the pupil is required to stand four or five minutes or more, he should be directed to change from this posture by placing one foot slightly in advance of the other, after the manner of the public speaker, Fig. 46, and to vary this from time to time by placing the other foot slightly in advance and bringing the weight upon the leg which had previously been favored.

Additional suggestions — Bad postures in sitting are more injurious in their effects than bad postures in standing, as they are usually maintained for much longer periods of time than the bad postures assumed in standing. Sitting at the seat with one leg crossed over the other induces malformations, especially in girls. Improper postures have a decidedly more injurious effect upon girls, as a general rule, than upon boys. The more varied and greater amount of physical activity indulged in by boys unquestionably counteracts to a considerable extent the effects of bad postures upon them. Because of the lesser variety and amount of physical activity on the part of girls, their general muscular habits become confirmed at an earlier period than the muscular habits of boys. This emphasizes the great importance of watching more closely the posture of girls, and of exercising the utmost care to prevent, if possible, improper postures from becoming habitual. It may be added, in conclusion, that malpositions from wrong postures become fixed in a much shorter time in pupils that are poorly nourished.

Responsibility on the home as well as the school — It must be remembered, however, that the school cannot be expected to prevent malpositions unless aided by the home. Malformations arising from bad habits of posture are frequently chargeable to the home itself. Take, for instance, the habit so prevalent among girls of carrying books propped upon one hip. If one will observe any group of high school girls or girls of the upper grammar grades on the way to or from school, he will realize what effect a habit of this kind, kept up for four or five years, must have in producing malpositions of the body. The books rest in an oblique position supported by the left arm and left hip, as a rule. In this case, the left shoulder sags, there is a lengthening of the right side with a corresponding shortening of the left, causing the ribs on the left side to approach each other and those on the right to diverge from each other, and giving the spine a lateral curvature with its concavity toward the left. To counteract the force of gravity, the head is thrown slightly over to the right.

The school can do little more in this matter than explain to pupils the injurious effects that ensue from the habit of carrying books in this fashion. Such explanation will doubtless exert some influence in checking the practice. Its abolition, however, devolves, not upon the school, but upon parents.

Physical exercise — The tendency in schools gener-

ally is to overemphasize intellectual development and the acquirement of recorded knowledge, by filling every available minute of the school programme with requirements designed to accomplish these ends. Despite all that has been written of the dependence of mental development upon physical development, there has not yet been accorded to physical culture the place in our schools which its importance demands. How best to secure physical culture is undoubtedly the question of greatest importance in education at the present time. While perhaps the time has not come for according to physical culture its rightful place and share of time in our schools, and the reorganization of curricula and daily programmes on the principle that thorough mental development cannot be brought about without opportunity for full physical development, yet there is need that greater attention be given to physical exercise, and that it be accorded a greater amount of time in the daily programme than it now receives. While we recognize that there is a growing appreciation of the need and value of giving a certain amount of time each day to physical exercise, yet we find that in the majority of schools the physical organisms of pupils are not only pretty largely neglected, but that deteriorating conditions are tolerated against which the growing child must struggle.

The recess — About fifteen years ago a movement began for the abolition of the old time mid-forenoon

and mid-afternoon recess. Very plausible arguments were advanced to show the good which would follow such a change. Experience, and also new knowledge of what is necessary for the development of the motor areas of the brain, show the speciousness of most of those arguments, and the educational shortsightedness of that change. Happily there is now evident a tendency to return to the old-time recess.

A recess of not less than fifteen minutes during the morning session and again during the afternoon session, when all pupils, if the weather and climate permit, go out of doors and engage in some form of physical activity, is of incalculable value in its results upon physical health and mental development.

The freedom which the pupil feels is his during recess fosters spontaneity in play and in a varied round of games. In play, whether free or in a game, his spirits are joyous, the very activity in which he is engaged is a delight to him, thus attesting that nature's demands for the child are being properly met. The whole nervous system becomes accordingly invigorated.

The physical activities which the recess directly promotes counteract to some extent the tendencies which improper postures exert toward malformations. Through the fuller breathing which physical exercise compels, the circulation is equalized and the blood oxygenated.

Daily periods for physical exercise — Besides the physical activity which the recesses afford, there should be given to each grade, every school day, at least two short periods of systematic physical exercises, designed to promote quick and strong muscular control of the various parts of the body, to equalize the circulation which mental effort combined with sitting at the desk has rendered more or less uneven, to give proper carriage to the body, and to expand and enlarge the chest so that deep breathing shall become a fixed habit. In a system of exercises designed to secure these results, care must be taken not to overtax the heart.

An eclectic system of physical exercises carefully chosen is preferable to adherence to any particular system. The Swedish system, it may be remarked, seems too rigid, too severe. There is a monotony about it, and it puts too great a strain upon attention. The periods devoted to physical exercise should afford a relief to the mental powers, and serve to recuperate the mental energies instead of further taxing them. With a proper system, a period of physical exercise should in its employment excite in the pupil's mind a sense of pleasure. The Swedish system as ordinarily practised does not appear to be attended with such results.

It must not be supposed that apparatus is indispensable to the carrying out of a system of physical exercises. It is possible without any apparatus whatever to

give simple movements that will exercise nearly all the muscles of the body. Apparatus, however, has its advantages, and if it can be had it will impart diversity to the work, and, besides its general serviceableness, will give opportunity for special exercises designed to correct individual defects.

CHAPTER IX

Eyesight and Hearing

Adequate lighting of the schoolroom not the only requisite — In the first chapter of this book great stress was laid upon the proper and sufficient lighting of the schoolroom. The severe tax put upon the eyes by the conditions of the age in which we live renders it highly incumbent upon teachers and school authorities to see that every care is taken not to overtax the eyes of pupils during the period of school life. It must be admitted that up to the present time the care which the importance of the matter demands has not been exercised. School life impairs more or less the eyesight of the greater number of those who pass through the grades. Our progressive civilization seems destined to tax the eyes to a still greater degree in the future than even at present, if we may judge from the growing demands of the past. The school is therefore culpable if it, through disregard or even through neglect, fails to use every means and to take every precaution against impairing the eyesight of pupils.

But proper and sufficient lighting of the schoolroom, while a most vital matter, is not the only care that must

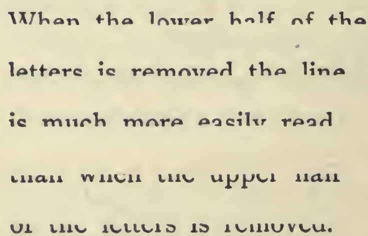
be exercised to prevent impairment of eyesight. The size of the letters in the text of school books, if below a certain standard, will prove harmful to eyesight.

Vision impaired by texts printed in too small letters—It is not as widely known among teachers as it should be that the small letters of the alphabet differ as to their relative degree of legibility. The investigations of the French oculist Javal, of Dr. Cattell, and of Dr. Sanford, in this particular, have brought out a number of interesting and valuable facts that have a practical bearing on certain phases of school work.

It is unnecessary in this work to enter upon a description of the methods used in making these experiments. The results are of practical importance, and it is yet to be explained why the makers of type and the publishers of school books have not availed themselves more fully of the valuable conclusions of these investigators, embodied their suggestions in modifications of certain letters, and introduced modified forms in the printing of school books.

It was proved by these investigators that the small letters of the alphabet are not equally legible. The most legible letters were found to be w, m, q, p, v, j, and f. The letters h, r, d, g, k, b, x, l, n, and u were classed fair in comparison with the other letters as to legibility, while the letters a, t, i, z, o, c, s, and e were pronounced poor as to legibility. It was discovered that the letters c, e, and o are often taken one for the other, and accord-

ingly are easily confusable, and that i tends to be confused with l, a with s, h with b. The letters g and a are mistaken for several different letters. s proves to be a hard letter to recognize. A moment's examination of the letters h and b will show that they would tend to be confused with each other; for it must be remembered, as Javal has shown, that in reading, the eye does not examine all parts of each letter, but fixes its point of clearest vision so that it runs along a horizontal line, which cuts the letters just below the tops of their main part, as in the example inserted below. It seems natural for the eye to move in a horizontal direction, in order to avoid fatiguing movements. The line, therefore, which the eye follows is dependent upon the particular shape of the printed letters. By running the eye over the



example given, the reader will appreciate the truth of this statement, and he will also see how much more easily the lines may be read when only the upper parts of the letters are given than when these are removed and the lower parts left. It will be readily seen from this how an h may be confused with a b.

A knowledge of the facts in regard to the relative legibility of the small letters, and of the possible confusion of certain of those letters, is of practical value to teachers. Such knowledge will enable teachers to understand some of the mistakes of substituting one letter for another made by children in learning to read and spell, and to guard the child against making such mistakes.

Alterations needed in the forms of letters — The slight alterations in the form of letters which have been proposed by these investigators in order to make reading less fatiguing to the eye, we believe it would prove of value here to state. First, then, if letters are enlarged, and, therefore, their different parts increased, the letters will thereby be rendered more legible. Further, if what have been called the internal spaces of the letters are enlarged, it will give the letters greater breadth in certain particulars, and therefore render them more legible. If the areas of black and white are each more in a mass, the letters are accordingly increased in legibility. These investigators have shown that irradiation also plays quite an important part in rendering letters illegible. Some explanation of this phenomenon will make the suggestions of these investigators readily intelligible. If, therefore, the reader will hold his lead-pencil across the flame of the lamp or gas jet, he will notice that the lead-pencil appears very much smaller where it crosses the flame. This is due to the fact that the rays of light

from the flame are more intense than the light reflected from the pencil, and are more overpowering in their effect upon the retina, and hence we attribute to the intenser rays a greater area than they really cover.

Another illustration of irradiation, but not so marked a one, is afforded by the squares in Fig. 47. The inner

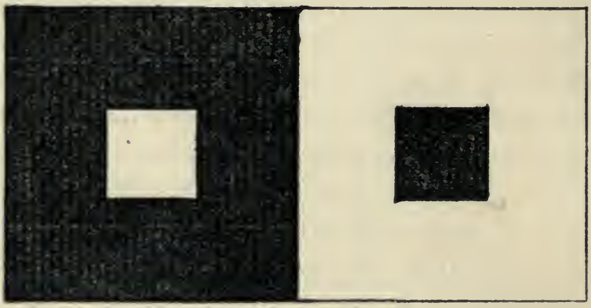


FIG. 47.

white square seems larger than it actually is, and the inner smaller black square of lesser area than is actually the case, due to irradiation, as we have just explained. Because, then, of irradiation, the white paper upon which black letters are printed seems to produce a rounding effect upon the smaller outer corners of the letters. Accordingly, it was pointed out that the ceriphs at the top and the bottom of h, s, and z should be made triangular in shape rather than linear. It was further suggested that c and o should be made broader and more open in form, and that an earlier style of a, for example ∂, should be

used; that the dot of the i should be as high as possible above the stem, made heavier, and the thickness of the stem increased to match. A form of e like the following, e, was recommended, in order to avoid the confusion of e and c. The recommendation was also made that the projection at the top of the f and at the bottom of the j be made heavier and longer, and that in u and n the opening be widened a little at the top of one and at the bottom of the other. As s is a hard letter to see, an excellent suggestion made by Dr. Sanford was that a form of s like the following, ſ, be used.

These suggestions have been adopted to some extent by type makers, but to nothing like the extent which they deserve. Type embodying these recommendations and suggestions should be made, and our school books printed from such type.

Proper size of type for school books — We are indebted to Dr. Herman Cohn of Breslau for much valuable knowledge in regard to the hygiene of the eye. He would prohibit the use of books in school having letters of less than a certain size. He demands that the height of the n shall be at least 1.5 mm. and its down stroke .25 mm. thick, any type smaller than this being injurious to the eyes. Cohn also demands that the smallest distance permissible between the non-loop letters of different lines, that is, the interlineage, shall be 2.5 mm. By reading the following

lines, in the same size of type, one specimen being unleaded and the other leaded, it will be seen that there is a great difference in legibility, the leaded type, or that of wider interlineage, being the more easily read, and, therefore, less fatiguing to the eye.

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Cohn also makes an important recommendation in relation to the length of the line. The shorter the line, the less fatigue it produces. A short line is easier to read because the eyes have to be moved less. As the eyes are focussed for the ends of the line, there is, with a long line, a stronger accommodation for the middle of the line. The greatest length of line which Cohn would permit is 10 cm. (4 inches).

Measurement of the size of the letters of school books now in use reveals the fact that there are not only many whole books printed in too small letters, but also a very great number of books, each having

many parts printed in letters so small that the books must prove extremely injurious to the eyes of pupils who use them. Furthermore, the illumination in the greater number of our schoolhouses, on cloudy days and overcast days, falls so far below what is needful, that it is not sufficient that the size of letters in school books should just meet the requirements set forth by Cohn. Even in using books which just meet Cohn's requirements, myopia is rapidly increased on all days when the illumination of the schoolroom is deficient. There are many school books issued in which the type is 1.6 mm. with leading 3.5 mm. Such books are to be preferred to those in which the type just reaches the requirements of Cohn. Principals, teachers, and school superintendents should possess a millimeter measure and a magnifying glass, and should subject every book presented for their examination to a test to determine whether the size of the letters and the width of the leading are of such dimensions as will not prove injurious to the eyes of children. If every book, no matter what its merits, were rejected if its type were too small, the makers of such books would very quickly bring out new editions with a proper size of type. In the lower grades, the type in which books are printed should be much larger than the smallest permissible size allowed by Cohn. For the first year the size of type should be at least 2.6 mm. and the width of leading 4.5 mm. as shown in this example:—

Then there is a turn in the road. The long train runs over the bridge and swings round behind a hill.

The children cannot see it now.

For the second and the third year, the letters should not be smaller than 2 mm., with a leading of 4 mm. Some of the more carefully made books for the second and the third years are printed in letters of this size, as shown in the following example: —

She must climb the tree. She held on, first to one branch and then to another, and tried to reach the golden plums. Her hands, her face, and her feet were scratched and torn by the thorns. Try as hard as she could, she

For the fourth year, the letters should be at least 1.8 mm., with leading 3.6 mm., as follows: —

On the way down, an Indian who was in a canoe stole something from the ship. One of the crew saw the Indian commit the theft, and, picking up a gun, shot and killed him. This made the other Indians very angry and Hudson had several fights with them.

Griffing and Franz, in their investigations into reading, state that fatigue increases rapidly even before the size of the type becomes as small as 1.5 mm. They also say that additional leading or spacing between the lines is desirable. It is therefore warrantable to hold that for all years above the fourth year or grade the smallest size of letters allowable in books is 1.6 mm., and the narrowest leading 3 mm.

Color and surface of paper for school books — The kind of paper used in text-books is of importance. A paper that is grayish in tone is to be avoided, because it absorbs light to such a degree that the contrast between the black color of the letters and the gray of the paper is so decreased that the legibility of the letters is considerably lessened. A flat, unreflecting surface is necessary for school books. Books printed on glossy paper reflect light and are therefore injurious to eyesight. Griffing and Franz pronounce yellow paper unfavorable for reading.

The size of writing on the blackboard — Another source of strain upon the eyes of pupils is to be found in the writing displayed on blackboards. Blackboards are used to a very large extent for writing down examples, exercises, and questions, which are to be copied by pupils, or which they must read in recitation. It will be seen, from what has been said upon irradiation, that, other things being equal, a white mark on a black surface has an advantage over a black mark

on a white surface. The letters written with crayon on the blackboard would therefore seem to possess an advantage as to legibility over the same letters printed in black on a white ground. Other factors, however, come in to affect the conditions. Blackboards, especially if of slate, are decidedly grayish in color, and the small particles of crayon dust which cling to boards after being cleaned with an eraser render them a still lighter gray. It is evident, then, that we have not a strong white on a ground of strong black, but instead a white upon a grayish ground. The size of the writing on the blackboard becomes, therefore, a very important matter, if proper precaution is to be taken against all deteriorating influences upon the eyes of pupils. If we take 1.5 mm. as the smallest type permissible in school books, and remember the demands of oculists that no book should come closer to the eye in reading than 12 in., it is an easy matter to calculate what should be the size of the letters written on the blackboard, in order that they may be seen without undue strain upon the eyes of a pupil sitting in the last row of seats in the standard schoolroom. Having, then, the board as thoroughly cleaned as possible with erasers that are free from accumulated crayon dust, the non-loop script letters should be not less than $1\frac{3}{4}$ in. in height for the upper grammar grades. For children in the primary grades, the size of the non-loop letters should be much larger than

this. All writing on the blackboard should be in the vertical round hand, because of its greater legibility.

The use of slates injurious — It will be seen from what has been said in relation to blackboards that slates are extremely injurious to the eyes. Experiments have been made testing the legibility of letters written on the slate and letters of the same size written with pen and ink on ordinary white paper, and the difference in legibility has been found to be as great as 3 to 4. When in addition to this we remember that slates become greasy, it will be seen what a tax the use of slates entails upon the eye. It is not to be wondered at, then, that some oculists have emphatically demanded the exclusion of slates from the schoolroom.

Copy-books — Copy-books may also be a source of strain upon the eyes. The paper of copy-books should have the least possible gloss, and the books should have the least possible ruling. The length of the lines of the copy-book should not be greater in all of the lower grades than 5½ in. Copy-books should have no other ruling than the base line, and this should be printed, as in many of the English copy-books, because the color of ruled lines is so faint as to be a source of fatigue to the eyes.

Color of writing ink — The color of the ink used in writing must also be looked after, if we would lessen the factors that produce visual fatigue. Ink should leave a jet-black mark as soon as it touches the paper, and all black inks that are bluish or purplish or greenish in shade

when first used should be excluded from the schoolroom. Precaution should be exercised to see that the ink is not watered by the janitor, as is frequently the case, and thus rendered pale. Much labor will have to be expended to care for ink wells properly, and to keep the ink in proper liquid condition, especially in the dry air of our schoolrooms. Labor and care in this matter cannot be avoided.

Postures — Bad postures in reading and writing affect seriously the eyesight. The pupil should sit erect in reading and in writing. His book should not come nearer the eye than 12 in.

Too much writing imposed on pupils — Another great factor in impairing the eyesight of pupils is found in the excessive amount of writing which is imposed upon children in school. There can be no question that there is entirely too much written work required in our schools. Much of it is done as seat work, and serves mainly the purpose of keeping the child employed, a purpose which is exceedingly reprehensible in itself, and a practice extremely uncomplimentary to the inventive power of teachers as to educative ways and means. As little reading and writing as possible should be given the child under ten years of age. All home lessons and exercises which require to be wrought out or accomplished by gas or lamp light are to be withheld from children below eleven years of age.

Use of fine maps — Let it be further remembered that

the search for places on maps that contain many names in fine print, and the drawing of maps in fine detail, are exceedingly injurious to the eyes.

Duty of parents — Parents must assist the school in its efforts for normal conditions for eye work, and should have a close scrutiny over children at home to prevent them from reading at night or in the waning light at the end of the day. Children when they have learned to read will need to be closely watched in this particular. They have little apprehension of the fatigue of their eyes, and frequently when they are partly aware of this the interest in the book makes them oblivious to the strain that they are putting upon their eyes.

Sewing — Needlework by pupils is another source of danger to eyes, and exercises in needlework are to be allowed only when the illumination is the very strongest, and to those pupils whose eyes are strong. All fine needlework is to be excluded. Sewing with black thread on black cloth is especially to be avoided.

Tests to determine roughly amount of illumination — We have alluded several times in this book to the fact that schoolrooms that are well illuminated on bright days are too often deficient in illumination on dark days. Under such conditions the teacher must exercise great care to see that on days when the illumination is insufficient all fine work with the eyes, such as would be permissible on bright days, is avoided. Two tests are suggested by which the teacher may determine what the

illumination is, and whether it is sufficient for certain kinds of work, as well as to determine whether pupils are sitting in a part of the room that is not sufficiently illuminated. The first test is that suggested by the *Medical Record* of Strasburg. According to the *Record*, a pupil should be able to read at 12 in. distance, and without strain, diamond type. For example: —

He went on up the river until the place was reached where Albany now stands. Here the little "Half Moon" was anchored. Indians came running down to the shore in wonder at the sight of the strange vessel. They brought with them strings of beaver skins, which they gave Hudson in exchange for pieces of gold lace, glass beads, and other trinkets. Hudson was quick to see the importance of this fur trade, and took back with him many valuable furs. Here the stream had become narrow, and was so shallow that the captain feared his vessel might run aground. He knew at last that the water was a river and not a strait, and that he was not likely to find here a passage to China. So Hudson, turning back, started down the river.

If pupils are in a part of the room where they cannot read the above lines at 12 in. distance without apparent strain, the illumination is dangerously low.

The second test is using a line of Cohn's Test Type (Fig. 48).

FIG. 48.

If the pupil at 20 ft. distance is unable to make out the direction in which the E's open, the illumination is so low as not to permit the use of the eyes on text-book or in writing.

Artificial light — The hygienic requisites for artificial lighting of schoolrooms are sufficient illumina-

tion, steadiness, absence of color tending to produce visual fatigue, and non-vitiation of the air. It is claimed that these requisites are more completely met by a certain form of arc light used in the lecture rooms of some of the German universities than by any other kind of illumination. This form of arc light is so constructed that the direct rays from the arc do not fall upon the desk. A reflector surrounds the arc and all the lower rays are reflected to various parts of the ceiling and are here combined with the upper rays of the arc. In this way the light falls well diffused, it being reflected from all parts of the ceiling, which, of course, is white in color. This diffusion of light lessens the intensity of shadows which would be produced by the direct rays of the arc. The illumination from this kind of arc light is very steady. It is not likely, however, to be much used in this country for several reasons. In the first place, its mechanical construction and the attention this requires would not commend it to American mechanical approval. Further, arc light wiring is not favored in school buildings; and lastly, the recent appearance of prismatic globes, constructed according to the laws of geometrical optics, offers a simpler and more economical means of diffusing and distributing light.

The incandescent electric light is quite widely used in schools for artificial illumination. One disadvan-

tage of this light is its yellow color. The yellow rays falling on the paper give to this a yellowish tone, thus decreasing the contrast between the letters and the surrounding parts of the page, and causing the print to fall off somewhat in degree of legibility. According to Griffing and Franz, yellow paper is unfavorable for reading, and yellow light, causing the paper to appear yellow, must also be a source of fatigue.

It is to be further noted that the glowing film of the incandescent electric light, when it comes across the line of vision, is extremely fatiguing to the eye. The reflection, moreover, of the glowing film from the glass bulb throws a peculiar shadow on paper or page of book under it, which is harmful in a high degree to eyesight. A just regard for the eye requires, therefore, that the glowing film of the incandescent light should in some way be shielded. Economy dictates that whatever shield is used should not appreciably decrease the illuminating power of the light. When shielded with ground glass or the various kinds of translucent shades, the illumination is largely reduced, dependent upon the kind of shade. When shielded, therefore, a greater number of incandescent bulbs would need to be supplied in order to afford sufficient illumination.

The Holophane glass globes possess the scientific merits of so distributing and diffusing the light as to

increase its effectiveness at the points most needed, namely, those below the horizontal. By inspection of the curves of distribution in the accompanying diagram,

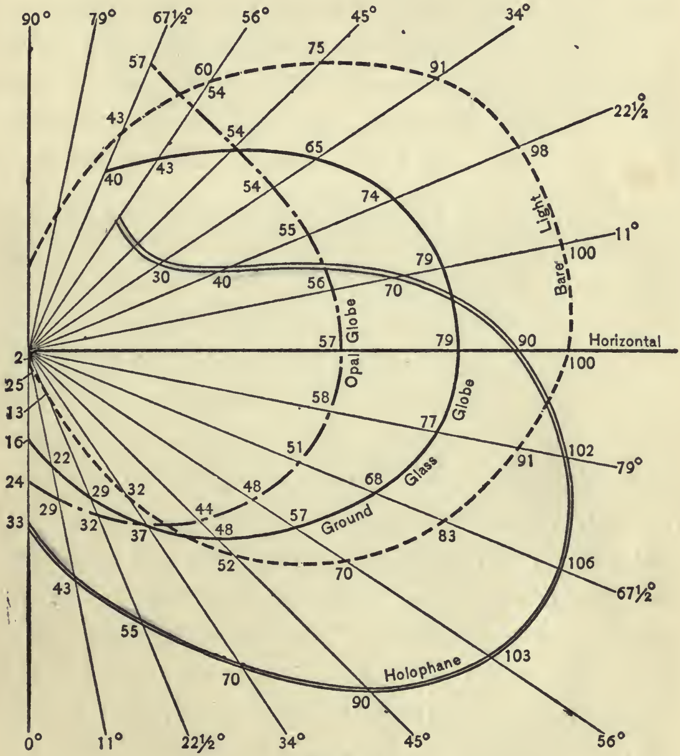


FIG. 49.

Fig. 49, the amount of light transmitted and distributed by a Holophane globe as compared with a bare incandescent bulb, with a ground glass globe, and with an opal globe, is shown. The intensity of the

light given out at the horizontal is called 100. The intensities at different angles of distribution are readily seen: for instance, at 56° from the vertical, the intensity of the light transmitted by a Holophane globe is 103 in comparison with 70 for the unshielded bulb, 57 for ground glass globe, and 48 for opal globe. These intensities, established by photometric measurements, show the economy and effectiveness of this kind of prismatic globe.

For a schoolroom where incandescent electric light is employed, the most effective illumination may be secured by using the form of Holophane globe shown in Fig. 50, and placing this as close to the ceiling as the fixture will permit. Incandescent electric bulbs usually depend from the ceiling 3 or 4 ft. With the use of the Holophane, the bulb would need to be brought very much nearer the ceiling.

In Chap. IV, we have stated that a gas jet burning 4 ft. an hour would consume the oxygen from 21 cu. ft. of air, besides the impurities which it would disseminate in the air. In rooms, therefore, not thoroughly ventilated, the avoidance of further vitiation of the air by the use of electric light is of very great importance.

In most schools, however, gas light is still used for artificial illumination, not only in evening schools, but also in day schools during the fall and winter months in many rooms where the proximity of other

FIG. 50.

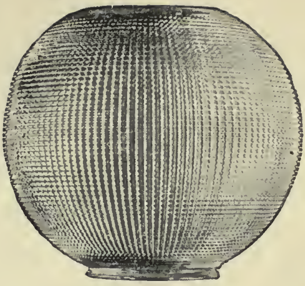


FIG. 53.

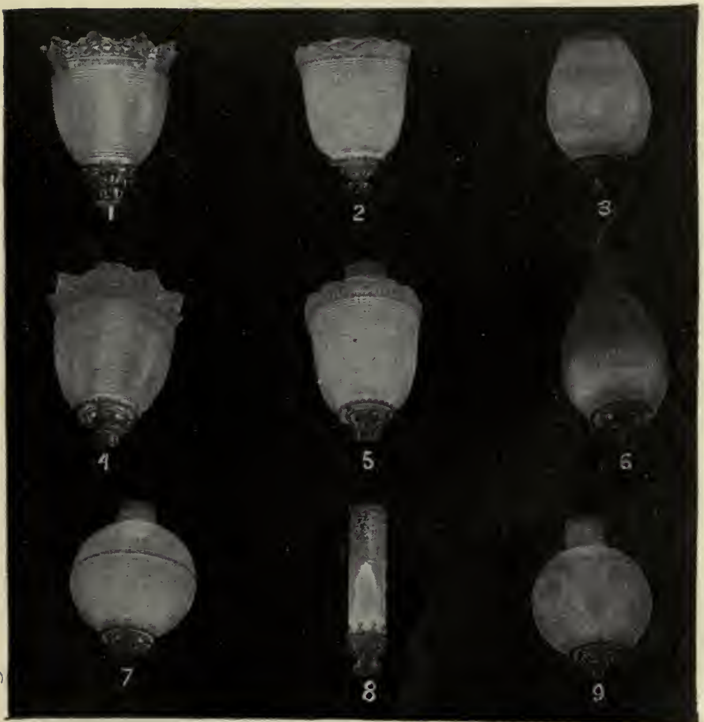


FIG. 51.

Globes 1 and 4 have simple horizontal prisms on the outside. Globes 3 and 6 vertical prisms on the inside. 9 is a frosted globe. 8 is the bare Welsbach light. Globes 2, 5, and 7 are Holophanes.

buildings and the small amount of transparent glass surface render the room so dark that classwork would be impossible without artificial illumination. The ordinary gas flame gives a yellow light, it does not burn steadily, and in these respects produces illumination unfavorable for the eye. If gas must be used for artificial illumination, the color of the light from it may be changed and the unsteadiness of the flame remedied, by the use of a round burner with an incandescent mantle, known as the Welsbach burner. This burner consumes less gas than the flat flame and emits a light of much greater intensity. At the same time it has not the objectionable yellow color. The light is white possessing a faint greenish tinge. This ought not to be objectionable for schoolroom illumination, but it may be neutralized by substituting for the ordinary glass chimney a rose-colored one.

A stronger objection to the unshielded Welsbach burner may be entered than that already made against the bare bulb of the incandescent electric light. The intense light of the incandescent mantle must be shielded as an absolutely necessary protection to the eyes of pupils.

The Holophane glass globes, by the refractive properties of their prismatic ribbings, completely hide the incandescent mantle, and appear themselves to be the source of a soft, diffused light. The accompanying cut, Fig. 51, made from photographs, shows not

only the remarkable qualities of these globes in this particular, but also gives a comparison with other kinds of globes used to soften the glare of an incandescent mantle.

The distribution of the light and its effectiveness below the horizontal attained by covering a Welsbach burner with a Holophane globe is shown in Fig. 52,

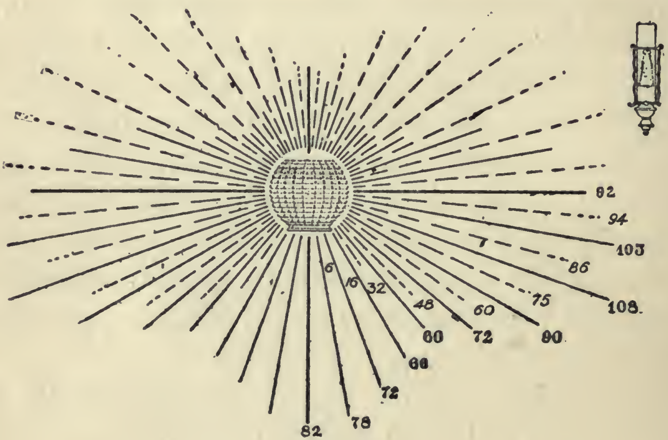


FIG. 52.

the numbers at the end of the radiate lines indicating the degree of candle power; the dotted lines representing the ordinary Welsbach burner, the solid lines the burner covered by the proper form of the Holophane globe. The proper form for schoolrooms fitted with ordinary dependent inverted T gas jets is shown in Fig. 53.

If the source of illumination is only the ordinary

flat gas flame, a proper shape of Holophane globe will increase greatly the effectiveness of the illumination of the room by directing the greater part of the light downward upon the desks, and will also impart by its diffusion a greater steadiness of illumination.

In artificial illumination of schoolrooms, care must be exercised that the light is not placed too near the eye, and also that it is far enough above the desks so that the warm rays from the light will not heat the head of the pupil, as this is injurious.

How to test the eyesight — No teacher should go on day after day giving instruction to children and assigning tasks to them without knowing, even though roughly, whether any number of those in the class are suffering from the common defects of vision. Through a lack of knowledge in this respect on the teacher's part a pupil may be seated where the illumination is inadequate for him, or tasks may be required of him that might have been lessened, and thus a rapid deterioration of his vision ensue. Tests to ascertain the most common defects of vision may now be so easily made that there is no ground of excuse for any teacher's not knowing and making them. One State now requires that such tests shall be made once a year. Children who are found to be short-sighted should be seated near the front of the room, where it will be least taxing for them to see what is placed on the blackboard. Children are often taken

to task for mistakes and regarded as dull, when the cause is frequently want of visual power.

Every child's eyesight should be tested as soon after entering school in the fall as possible. Defects either of short sight or long sight should be at once reported to the parents, in order that an examination by an oculist may be sought and proper glasses provided. The tests recommended below, it must be remembered, will reveal only the presence of common defects; the precise nature of the defect must be determined by an oculist.

At the end of this book, Fig. 60, will be found four lines of letters of different sizes. These are taken from Snellen's Test Letters, now generally used and therefore possessing the advantage that records made with them may be easily compared. Cut out the sheet, and paste it smoothly on a piece of cardboard, as this will afford the most convenient and reliable way of making tests. By reference to the sheet, it will be seen that each row of letters has a certain number of feet marked below it. This number indicates the distance at which the particular letter can be read by the normal eye. Thus the largest letters have 60 ft. marked underneath them, which indicates that these letters should be easily seen 60 ft. away. The smallest row has 20 ft. printed underneath it, indicating that these letters should be easily read at a distance of 20 ft.

To test for acuteness of vision the letters should be hung on the wall in a good light, and on a level with the pupil's eyes. The illumination of the card should be equal to that which has been required for the standard schoolroom. Measure 20 ft. perpendicularly out from the wall on which the card hangs, and draw a line upon the floor. Let each child who is to be tested stand with his toes to this mark. Then direct him to read the letters row by row, beginning with the upper row. Each eye is to be tested separately, and the right eye should be tested first. The pupil should hold a piece of cardboard in front of the eye that is not being tested, in order to obstruct its vision. Care must be taken not to press against the eye which is not being tested, with the cardboard. The vision of each eye is to be recorded separately. If the pupil reads the last line correctly, then his vision is to be regarded as normal, and it is recorded as R. V. $= \frac{20}{20}$. In this record the numerator represents the distance that the types are away from the eye of the pupil, and the denominator 20 represents the distance at which the normal eye should see the last row. If the pupil is able to see only the row marked 30 ft., then the record would read R. V. $= \frac{20}{30}$. If the third row from the bottom, then the record would read R. V. $= \frac{20}{40}$. If it should be found in testing the left eye that the record reads L. V. $= \frac{20}{40}$, it will be seen that the left eye is short-

sighted, and that we have an impairment of vision here which should be remedied, if the pupil is to be put in a condition to use his eyes with the least possible strain. When it is found that the vision of the pupil equals $\frac{20}{60}$, then this condition should be at once reported to parents or guardian, in order that expert advice may be taken, and proper means supplied for obviating the defect. A record of the test made upon each child should be kept in a small book from year to year, so that the record of previous tests may be compared with the last test, in order to learn whether, if defects existed, they are becoming worse. For example: Mary Rogers, October, 1899, R. V. = $\frac{20}{20}$, L. V. = $\frac{20}{20}$. Willie Rose, R. V. = $\frac{20}{30}$, L. V. = $\frac{20}{30}$.

Some children are long-sighted, but this is not so easily detected, owing to "active power of accommodation" in children. The oculist suspends the power of accommodation by dropping atrophine into the eye, and is then enabled to determine accurately how much the eye is far-sighted. This, however, could not be done by a teacher, and his only means for detecting far-sightedness is in placing the pupil at a greater distance from the smallest size of type than 20. ft. In testing pupils, a case of long-sightedness might at first be regarded as short-sightedness, because the pupil would be unable to make out the letters of the lowest line at 20 ft. distance. There are some conditions of the eye which, if closely

observed by the teacher, will aid him in detecting cases of long sight. These conditions are redness of the eyes, which renders them weak and watery in appearance; the edges of the eyelids are frequently covered with a coating of dry matter. Pupils who have long-sight are likely to complain of headaches after protracted and close use of the eyes.

A scale devised by Monoyer of Paris, containing a series of letters of different sizes, is recommended by some for testing the eyes. This scale has been republished by Ginn & Company, Boston. It has the advantage of being mounted on cardboard with full and clear directions for making the tests printed on the back of the card.

How to test hearing — If we are to educate children, it is supremely wise to know as many of their physical defects as possible, and especially is this true as regards defects of the two most important avenues of sense, the eye and the ear; for only by means of this knowledge can the teacher work intelligently and avoid unnecessary strain on the part of the pupil and waste of effort on his own part. Careful investigations point to the broad fact that about twenty per cent of school children possess some defect of hearing, either in one or in both ears. It will be seen that the child of average ability who has some undetected defect of hearing will frequently be done an injustice, and rated as dull or inattentive, not through

any fault of his own, but because of a lack of knowledge on the part of the teacher of the true cause.

In urging that there shall be a test of vision and a test of hearing of every pupil at least once a year, the objection will be met with that teachers are already overburdened with what is required of them, that they are overtaxed by the conditions which are imposed upon them. As a rule this is true, and relief should certainly be afforded. There are two ways in which this may be done. First, a smaller number of pupils should be assigned each teacher, never to exceed forty. Second, better hygienic conditions in the schoolroom should be provided, especially in regard to thorough ventilation. With such relief afforded, there would be opportunity to attend to such important matters as testing the vision and hearing of pupils.

Of course records of the eyesight and hearing of pupils should come to the teacher from the medical inspectors of schools. Very few schools, however, have made any provision for medical inspection. Such inspection is a matter of the future, and will come in time. Meanwhile, with our knowledge of how these tests should be made and the necessity of them, there is no other way than for the teacher to make them. But help may be secured in this particular by obtaining the aid of the more intelligent pupils in the higher grades.

Of all the tests which have been employed in the various experiments for detecting defects of hearing, there are perhaps but two that are within the command of teachers in general. These are the test by means of a watch, and the test by means of whispering. In testing the pupils by the first means, an ordinary watch may be used. If a stop watch is available, it is preferable to an ordinary watch, as it can be stopped and started while being held in the hand. A tape line fastened at one end of the room and running down the aisle may be suspended from two and one-half to four and one-half feet above the floor, according to the height of the pupils to be tested. The numbers on the tape line should read away from the pupil who is being tested. He should stand back to the one making the test, and at the end of the tape line. If a tape line is not at hand, then the distance can be measured down the aisle on the floor in feet. The pupil is to close his eyes and to close the ear that is not being tested, either by holding a piece of cloth over the ear or by stopping the ear thoroughly with sanitary cotton. A handkerchief is not large and thick enough for this purpose. The teacher begins at a distance beyond the pupil's hearing and approaches him, and the pupil signifies when he can hear the watch and when he cannot. The watch should be moved back and forth upon the line. Care must be exercised not to touch the line with the watch, as this might

act as a conductor and vitiate, to some extent, the test. Five feet may be put down as a provisional distance for long hearing of the ticking of a watch. It will be remembered, however, that this is to be taken only tentatively, as conditions of the room so far as outside noises are concerned, and the difference in the ticking of watches, will have to be taken into consideration. The normal distance can be easily but roughly determined by the teacher by averaging the records of the various tests made.

The second method, that of whispering, can be used under substantially the same conditions which have been prescribed for the watch method, with the exception that the distance between the pupil and the teacher will need to be made much greater. The teacher whispers various numbers; 10, 30, 23, 33, 37, 28, are good combinations. Of course, the teacher must seek to whisper always with the same intensity, and the whispering must be done with expiring breath and not with inspiring. The distances at which pupils can hear must be collated and the normal distance determined from the records. After the determination of this, it is an easy matter to pick out those who do not hear from those who hear at the shorter or normal distance. Of course it is understood that each ear is to be tested separately and a record made.

The audiometer — The foregoing methods, however, are crude, and demand much time and patience. An

audiometer recently perfected by Professor Seashore of Iowa University now affords a quick and scientific means of testing hearing.

The instrument consists of a telephone receiver so arranged that when held to the ear a series of clicks may be produced by the manipulation of an electric current of different strengths. The instrument is so graduated that the sound of the clicks may be made to vary by the smallest perceptible difference, the difference being measured by the strength of the current used. The degree of auditory power, it will therefore be seen, is determined according to an arbitrary scale. The norm is reached by taking that point in the scale of each instrument which has the largest number of records set down to it after testing the ears of a great many average persons.

The hearing of several thousand children in the Chicago schools has lately been tested with this audiometer under the direction of Supt. F. W. Smedley. From these tests the conclusions are drawn that about one-sixth of all pupils are so defective in hearing in both ears as to interfere seriously with their progress in the oral parts of teaching, and that about one-sixth are so defective in one ear or the other as to show the necessity of giving them a seat on the proper side of the teacher.

CHAPTER X

HANDWRITING

Position in writing productive of spinal curvature — It is somewhat more than two decades since it was ascertained by physicians in Germany that as pupils advanced through the various school years there was an increased tendency to curvature of the spine, and that the number of cases among girls was much greater than among boys, about four times as many cases being found in girls as in boys. The establishment of this fact was followed by observations to determine what conditions in school life might be its cause. Very early in their observations physicians were impressed with the idea that the position assumed by children during the writing exercises tended in itself to produce curvature of the spine, the curve being convex toward the right. One may easily satisfy himself by observation that such a conclusion would naturally and inevitably arise in the minds of physicians interested in ascertaining the cause of the curvature, provided one stand at the back of a schoolroom and notice the postures into which children fall during the writing exercises. Investigations were accordingly undertaken to determine the hygiene of writing. These

were protracted over a long period. They attracted attention in America in 1892, and since that time investigations and tests have been made, which not only confirm conclusions reached in Germany, but also contribute new knowledge on the hygiene of writing.

There is not space in the present work to give an account of these investigations. We shall be obliged, therefore, to limit ourselves to a general statement of the conclusions arrived at in regard to writing. We shall then set forth a new method of teaching writing — a method that is now giving results much more satisfactory than those attained by any previous method. It may, however, be remarked that, notwithstanding all past observations, the hygiene of writing still affords ground for much careful investigation.

The results of the experiments and the tests made are unquestionably in favor of vertical script and the postures and freedom which necessarily go with the vertical or upright script. The differences in form between the vertical and slanting scripts are shown in the following examples:

Pay to the order of Charles G

London, the largest city in Europe.

The first example is the Vertical; the second the Spencerian, with long loops to the letters and with the down strokes of the letters having a slope of 52°.

The employment of the slanting script in teaching pupils the use of the pen conduces to curvature of the spine and imposes a strain upon the eyes which is injurious. In the first place, the writing-master's conventional way of holding the pen, which is shown in Figs. 54 and 55, inevitably results in a shifting of the copy-book or writing materials more or less to one side, usually making an oblique angle with the back edge of the desk. In learning to write the pupil must, of course, see what he is trying to write, and at the same time be able to look for some distance along the line on which he is trying to write. Let it be remembered also that the learner, because of inability to coördinate his muscles easily, grasps the penholder as close to the pen as possible. With the pen so held, the paper must naturally shift to the right and take meanwhile an oblique position to expose a sufficient length of line beyond the hand, in order to guide the pupil in bringing the letters he is

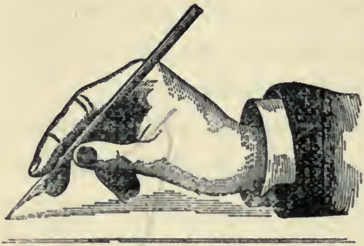


FIG. 54.

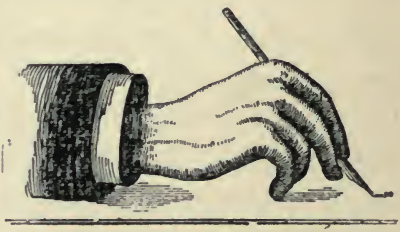


FIG. 55.

forming down to the line. Let the reader hold his pen in this manner and place the paper directly in front of him, and he will discover that in order to see what he is writing he must either drop his head to the left and a little forward, or move the paper to the right, placing it obliquely to the back edge of the desk. This position of the paper in writing raises the right shoulder, while the head drops over more or less to the left. In the second place, the left hand under these conditions is given little muscular activity, none whatever requiring much co-ordination. There is, therefore, little consumption of muscular energy in the left hand and arm, and as a consequence of these conditions the left arm drops down or is brought nearer the side, thus reënforcing the bend of the spine to the left.

The oblique central position and the imaginary base line — In one of the early investigations into the hygiene of writing, it was held that placing the copy-book directly in front, but turned obliquely to the back edge of the desk, as illustrated in Fig. 54, would enable children to sit in a proper position in writing, and yet use sloping script. It was known at that time that the eye sees vertical and horizontal lines easily, as compared with oblique lines, which it sees with more or less difficulty. In other words, it was known that oblique lines are more taxing to the eye than vertical or horizontal lines.

It was therefore asserted that with the copy-book in

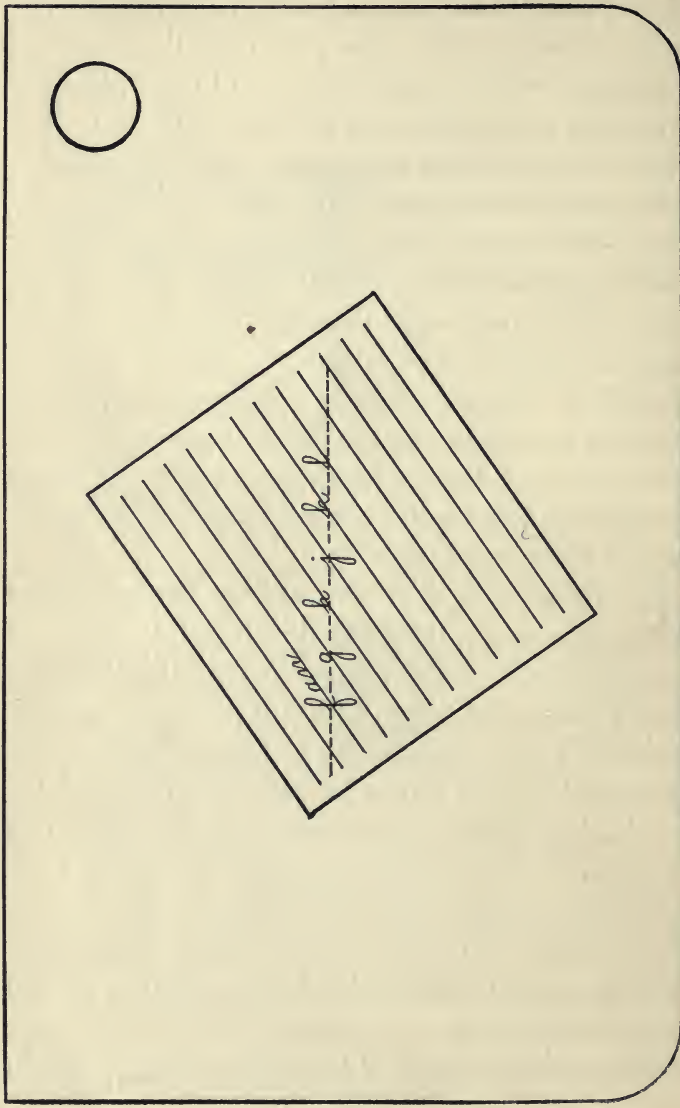


FIG. 56.

the oblique central position, the down strokes of the pen would be perpendicular to an imaginary line projected upon the paper and called the line of direction. This projected line was conceived to be formed by the intersection with the page of the copy-book of a plane joining the central points of the pupil's two eyes. This imaginary line cut the page as shown by the dotted line in Fig. 56. It will be seen that the down strokes of the pen, as shown by the script letters in the figure, would be perpendicular to this imaginary line, but the writing would be sloping with regard to the ruled lines of the copy-book.

The test of this theory in actual schoolroom practice was made, but the dropping of the head to the left and the bending of the spine in the writing exercises still continued.

Had certain facts since brought to light by investigations in America been known, this theory of the oblique central position of copy-book, with the down strokes of the pen perpendicular to an imaginary base line, would not have figured so prominently in the controversy that waged furiously during the protracted investigations into the hygiene of writing. Its misleading features would quickly have been detected. The facts alluded to are these. In learning to write, the pupil writes "uphill," so to speak; that is, the writing tends to diverge from the ruled line, for the reason that as the hand is moved away from one in

writing, the arm is straightening and, therefore, lengthening, caused by the increase of the angle made at the elbow by the forearm and the upper arm. The coördination of muscles necessary while writing, in order to draw the elbow constantly back as the angle opens, is a most difficult one to acquire, and is acquired later than the coördination of the muscles to produce merely the form of the letters.

The effort to overcome this divergence of his writing from the line causes the learner to give very close attention to the ruled line. In other words, his eye is constantly returning to the ruled line in order to bring his writing down to it. The line, then, is an object of very close attention to the eye. With the position of the copy-book we are speaking of, namely, the oblique central position, the lines of the copy-book are oblique to the eye. Since the eye sees horizontal lines easier than it does oblique lines, and since the eyes must be constantly noting the line of the copybook, the head naturally bends over to the left to bring the image of the ruled line as near as possible into the horizontal plane of sight.

The straight central position — On the other hand, a position known as the straight central position of the copy-book, as shown in Fig. 57, with the pupil sitting squarely in front of the book, and with the forearms placed equally on the desk, with the elbows at an equal distance from the pupil's side, was strongly advo-

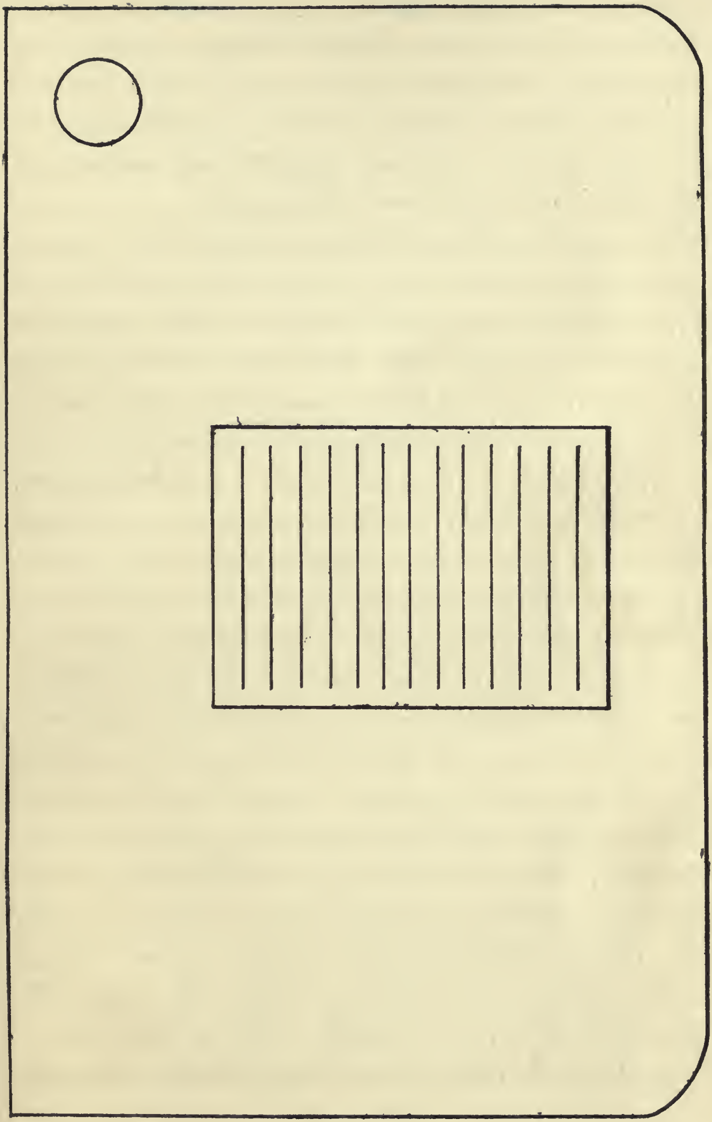


Fig. 57.

cated and defended, and introduced in several schools. Actual tests with the straight central position of the copy-book, prolonged and repeated, showed that the straight central position, with proper holding of the pen, enabled pupils to maintain good postures in writing when using the vertical script.

The reasons in favor of vertical script — The reasons in favor of vertical writing, adduced as the outcome of the investigations which extended over a somewhat long period of years, are, first, that it is the natural way of writing, as children, when they begin to write, write vertically. It is a fact well known to all first-year teachers that continual effort must be put forth to make the child acquire a slant to his writing. Second, that the vertical hand is easier for the eyes, as the eye sees vertical and horizontal lines with less difficulty than oblique lines. The upright script, because it is composed of vertical instead of oblique lines, has greater legibility, and is, therefore, less taxing upon the eye of the writer and the eye of the reader than slanting script. Third, that an unequal accommodation of the two eyes is not imposed upon the pupil as is the case in the use of slanting script. Fourth, that vertical script is a result arising naturally and necessarily out of maintaining a symmetrical and easy position of the body in writing — a position not conducive to lateral curvature of the spine.

Rules to be observed in teaching vertical script —

There are certain rules to be observed in teaching vertical writing, and if these are neglected, vertical writing possesses but two advantages from the hygienic point of view. First, it is much more legible than the sloping hand, and, therefore, less taxing upon the eyes; second, the pupil seems to have less difficulty in conceiving the form of the letters and in learning to coördinate his muscles so as to produce the forms.

Vertical writing, it must be understood, is not simply a reform in the shape of the letters by which the down strokes are vertical, the letters more round, and the loops of the letters shorter, instead of the down strokes being oblique, the curves sharper, and the loops of letters longer; but it is primarily a reform of posture at the desk and of holding the pen, and that when the pupil who is learning to write sits in proper posture, and holds the pen correctly, the down strokes of his writing are naturally vertical. Briefly stated, it is correct posture, and with this, as a necessary consequence, the vertical script.

In several schools in England and Scotland, the writer has seen hundreds of pupils writing a large, round, fine, vertical hand, and in doing so, assuming postures that were as productive in giving a curvature to the spine as if the pupils had been writing the slanting script.

The first rule for vertical writing is that the page of the copy-book is to be placed directly in front of the

pupil and parallel to the edge of the desk nearest the pupil, as shown in Fig. 57. The paper must not be placed the least distance to one side, but directly in front, so that the plane in which the median line of the body lies will cut the paper perpendicular to its lower edge in two equal parts. The writing paper must not be over $5\frac{1}{2}$ in. in width.

Second, the penholder is to be held so that the inside of the hand may be seen, the holder lying between the upper joint of the thumb and index finger. The point of the pen should be at least an inch and a half below the end of the second finger. Fig. 58 shows the correct way of holding the pen, while Fig. 54 shows the conventional way of the writing-master.

So much misconception and harmful error exist as to how the pen should be held in vertical writing, and so unsatisfactory results have in a great number of instances attended the adoption of vertical script because of this error, that we call especial attention to the matter here.

Proper way of holding the pen in vertical writing — An English advocate of vertical writing gives in his book the conventional way, as shown in Fig. 54. For reasons which have been set forth on p. 202, it will be seen that this way cannot be used and good posture maintained. It is, moreover, not the manner of holding the pen recommended by the German physicians to whom we owe so much for the careful and thorough investigations which instituted a reform in hand-

writing. Other reasons, moreover, may be adduced against the conventional way of holding the pen. It is very tiresome and difficult, so much so that teachers, long before the advent of vertical writing, had learned that, despite all their insistence, children in general could not be made to hold the pen in this manner. The tiresome difficulty of this method is explained on anatomical grounds. When the child tries to hold the pen in the conventional manner of the writing-master, the ulna and the radius are out of their natural position, the one being twisted over the other, and held so by a strong tension of the muscles. To maintain such a position, accompanied as it is by a somewhat rigid pressure upon the penholder by the thumb, index and middle fingers, is extremely fatiguing to the child.

In vertical writing, on the contrary, the ulna and radius lie in their natural position while the hand moves on the side of the little finger at the end joint and, if more support is necessary, on the projecting side of the hand near the wrist-joint.

In connection with this rule for holding the pen it is necessary to add a word of caution, to the effect that some individual freedom must be permitted each pupil, as hands are not all formed alike. However, the position of the hand and of the pen in vertical writing are markedly different from the conventional position of the hand and pen in slanting writing. In the conventional way the knuckles of the hand are thrown up and the

palm of the hand is down; in vertical writing the knuckles next the back of the hand and the palm are in an upright position, or nearly so. In sloping writing, the pen is held alongside the upper joint of the index finger, sometimes in front of this joint, and points over the shoulder; in vertical writing, the pen lies somewhere in the depression between the upper joint of the index finger and the upper joint of the thumb, and it points in a direction running outside the line of the arm. With this position of the pen, the ulna and radius lie so that there is not a strong tension of the muscles to hold them in their relative position. It will be seen, therefore, that because of this natural position of the hand, the pupil finds it easier to coördinate the muscles necessary for writing. When, however, there must be at the start a strong tension of the muscles to hold the ulna and radius in a difficult position, a hard condition is imposed upon the child in learning to write. Some, indeed many, are never able under such a condition to acquire thorough coördination so as to use the muscles for writing with ease and facility, and hence the angular and cramped handwriting so often seen.

Third, the pupil must sit squarely facing his desk, with his feet resting fully on the floor. Both forearms should be equally placed on the desk, and the elbows should be held about a hand's breadth from the body. Fig. 59, facing page 210, shows the correct posture. The top of the desk, it will be noticed, is drawn down

to a minus distance of 3 in., and the desk top has a slope of fifteen degrees.

It will be apparent that the elbows can be held in the position just stated only when the desk is of exactly the right height for the pupil sitting at it. If the desk is too high, the elbows will need to be thrown out from the body, for freedom of movement is most essential. To oblige the pupil to hold his elbows a hand's breadth from the body when the desk he sits at is too high for him, is to force him to take a constrained posture inimical to facility in coördinating his muscles. Easy writing demands easy coördination and control of the muscles involved.

One-third of the time during the first years of the writing exercise should be given to rest. Let the pen be put down and the pupil relieved of the strain and tension of muscles caused by his efforts to coördinate and to gain facility of movement through the coördinations.

In the end, it will also be found a gain to let pupils rise from their seats and relax the muscles which have become tired because of the inactivity imposed by sitting at the desk. After the interval, let the pupils take proper posture, dip pens, and write. Brief periods of writing, with intervals for rest, will be found to give the best results as to posture and the easiest acquirement of the coördinations of movements.

The principles of vertical writing not properly regarded — These principles, it is to be feared, have not been thoroughly understood, much less properly followed, in the rapid adoption and spread of the vertical script which the past eight years have witnessed in America. Copy-books and script charts for vertical writing have been abundant, but in too many cases with the same directions and illustrations as to pen-holding that belonged to slanting script. As I have already shown earlier in the chapter, the vertical hand with hygienic posture is incompatible with the conventional way of holding the pen employed in writing the slanting script.

Better postures secured with vertical script — It is to be said, however, that those who have used the vertical hand with as careful a regard for its hygienic principles as the desks and seats of their schools permitted, have obtained incomparably better postures than they formerly obtained with the slanting script. With the vertical script, seven-eighths of the pupils sit in good postures while writing. We cannot say excellent postures, for these cannot be obtained with the kind of desks now generally in use in the schools, and with the general custom of giving the child pencil or pen in the first school years, and requiring of him writing exercises in letters of small size.

Present methods of teaching writing condemned — Any teacher who will acquaint himself with certain

physiological facts and who will reflect upon their meaning, cannot fail to see that the usual methods of teaching writing are wrong from the start, and impose upon the child difficulties which in truth actually hinder his progress, fasten bad habits upon him, and at the end leave him, in a majority of cases, a poor writer.

It is not sufficient to adopt the vertical hand, and to provide seats and desks with proper slant and adjustable not only as to height but also as to minus distance. This in itself would constitute a great advance, if its adoption were general; but notwithstanding the gain such an advance would be, our present methods of teaching writing must undergo a very considerable modification in view of certain scientific facts bearing directly upon the matter. The new method must be wrought out from the point of view of hygiene, not from the point of view of the routine practice of the schoolroom. For such a method must be consistent with the newer knowledge, and not in violation of it.

Facility in writing easily and well involves an acquired power of initiating and controlling an innumerable number of motor impulses, so that they shall result in the simultaneous and successful movements of the muscles necessary to guide the writing instrument. Learning to write, then, is a matter of slow and difficult acquirement. Present methods of teaching writing

ignore the anatomical stages that should be closely observed, if the pupil is to be made the best writer he is capable of being made.

Let us consider for a moment the movements natural to the child when he comes to school. Comparatively speaking, the greater number of his movements are large and free. The movements of the muscles of the hand, the fingers, and the arm are not coördinated for guiding a fine point, as that of a pen or of a pencil, after certain linear forms. Yet we give him a pencil or a pen, put before his eyes certain forms, and set him to making those forms as best he may. When the child attempts to do this too many muscles act that are not necessary to the coördination. Not only do the various muscles that are necessary to produce the movement act, but other muscles not needed in the coördination act with them. It is the action of the muscles not necessary to the coördination which bothers the child, and marks his efforts as crude, uncertain, and painful. He makes every effort to guide and control the motor impulses as to their intensity, duration, and succession, but he succeeds in this only in a rude way. The child, it will be seen, cannot control the energy. Its flow is diffuse, passing more or less into muscles which are not necessary to the coördination. The movements demanded of him are, therefore, too fine, and require too delicate an adjustment. The coördinations and their succession required

of him are a long way in advance of his development in this respect. Not only, then, do we get awkward and uncertain movements of the hand from him, but there results, at the same time, a strain and rigidity of tension in the muscles of the hand and fingers which are tiresome and painful to the child in the extreme.

The great difficulty arises from the fact that the movements required have not been naturally developed. The whole task is thrown upon the child at one time — the delicate coördination of muscles to produce fine and exact movements, the inhibition of muscles not involved. Under these conditions there results, as we have said, a rigid tension of the muscles. Furthermore, it seems fair to assume that the fixation of the eyes upon the point of the pen and the pencil is also a factor in the producing of this rigid tension. Mosso is authority for the statement that there exists between the periphery and the centre such an intimate connection that patients who have lost the muscle sense can contract the muscles of the hand around an object and keep them contracted as long as they look at it. The friction of the pen also unquestionably enters as an adverse factor of influence in this rigid contraction of the muscles of the hand and fingers. For tests made by the writer clearly show that if the child is given a writing instrument which moves over the paper without appreciable friction, and with so blunt an end that he does not fixate his eyes upon

it, and is then directed to make comparatively large the letters he is writing, the rigid and cramped contraction of the muscles of the hand and fingers disappears. The resort to large movements with *pen* or *pencil* advocated by some teachers will not obviate, the writer feels assured from his tests and observations, the rigid tension of the muscles of hand and fingers in the first years of learning to write.

The method to be employed — Only crayon should be used during the first months when the child is learning to make letter forms, and all practice in writing should be on the blackboard. The size of this first writing must be adapted to the stage of development of the child's power of muscular coördination. In other words, begin as to size where the child is.

Some children will be able to make the first non-loop letters 3 in. in height. The muscular coördination of other children will be slower in its development, and they will need to make their non-loop letters perhaps 6 in. in height. This need not matter, as the children are writing on the blackboard. Gradually, as muscular control is developed by the child, the size of the non-loop letters should be reduced, until at length the non-loop letters are not more than 2 in. high.

Alternate use of right and left hand — The question of learning to write is almost wholly a question of effecting easy coördination of muscular movements, a question of the child's gaining control in proper

sequence over his muscles. It follows, then, that whenever he is required to make letter forms of small size which necessitate on his part muscular coördination beyond its easy and natural development, difficulties are imposed upon the child that unquestionably thwart true progress. It being, then, a question of the easy coördination of muscles, the development of control from the making of larger movements to the making of smaller movements, it will be found that the control of the right hand comes easier to the child if he is directed to use his left hand half or even a third of the time during the first stages of his learning to write. The reason for the advantage gained from this is not far to seek. In the free and active life of the child in play before coming to school, the energy has been drawn freely and to a considerable extent equally to each side of the body, and so expended. Here, then, we have a tendency somewhat strongly established, with which we must deal when we ask him to use his right hand in writing. When we require of him that he shall use his right hand in making letter forms, he endeavors to direct the energy into certain muscles, and to inhibit its flow into others. But, as we have already stated, the flow of the energy necessary to produce the movements required is diffuse, going into muscles not needed as well as into those needed; for he has not reached the stage of development in which he can direct the motor impulses into

the particular muscles, and effect any coördination, to the exclusion of others.

As the flow of energy has been about equal to each side of the body, the child, when he is using the right hand, must inhibit the flow of energy to the left side, and as he is able to do this to but a slight degree, the energy which has set naturally to the left side manifests itself in unneeded contractions. These may be recognized if the child is closely observed when learning to write. If, then, he uses the left hand a part of the time, it will be seen, first, that such use not only rests the muscles of the right hand, but it restores them to their uncontracted state; and when he returns to the use of the right hand, the very fact of relief and a new start gives him some gain in directing the energy into the muscles necessary, and the inhibition of its flow into the muscles not needed. Besides, by the employment of the left hand, the energy is used up which, as we have seen, would otherwise expend itself in contraction and uncontrolled movements of the muscles of the left arm and to some extent of the left side. It will be seen, then, that through this alternate use of the right hand and the left hand, the pupil is put into a position of advantage which helps him more readily to gain control of the muscles needed in the coördinations, and which also helps him to inhibit the flow of energy into the muscles not needed.

Some might make the demand, on assumed physio-

logical grounds, that the writing with the left hand should be such that its movements would be in correspondence to the movements of the right hand, or, in other words, that the script written with the left hand should read to the left. The acquirement of a habit of this kind would be of no value to the child. Moreover, it is not a question of developing the power to write with the left hand in a way corresponding naturally to the movements of the right hand in writing. It is a question of the value of the alternate use of the right hand and the left hand, a question of the child's advance in muscular control being enhanced by the use of the muscles of one hand for a time, and then the use of the muscles of the other hand for a time. Through that alternation, he comes in the easiest manner into the conscious power of control over his muscles.

Transition from writing at blackboard to writing at desk—The writer regards it most necessary that the use of crayons in writing on the blackboard be continued the whole of the first school year. The transition from writing at the blackboard to writing at the desk is a difficult one, and one in which the greatest care should be exercised. It will be seen that when the pupil writes at the desk many more of his muscles are inactive than when standing at the blackboard and moving along as he writes with the crayon. Fatigue soon follows from inactive muscles which the sitting in the

seat necessitates. Moreover, the muscular movements are somewhat different in making the letter forms on the slope of the desk from the movements when making them at the blackboard. The same freedom and ease, however, must be preserved. It will be found that here also some work must be given the left hand, or there will result strong contractions of the muscles from the natural set of energy to the left side. This set of energy to the left side manifests itself in the drawing of the left hand toward the side, the dropping of the head to the left, and the bending of the spine to the left, a posture harmful in the extreme to the child, and one requiring that every means should be resorted to to prevent it.

In the transition from blackboard writing to writing at the desk, pen and ink are not to be considered, and the ordinary lead-pencil is to be included in this category. It has been pointed out in an earlier part of this chapter that the friction of the pen or the pencil on the paper, and the fixation of the eyes upon the point, impede the easy coördination of the muscles on the part of the child. The friction, then, of the pen or pencil upon the paper, and the effects resulting from the fixation of the eyes upon the point of the pen, may be obviated by the use of a crayon composed of wax and pigment, and covered with paper. These crayons are known as the Franklin Checking Crayons, or Wax School Crayons. They make a

coarse black mark, and there is no appreciable friction in their use. There is no small point with its unfavorable effect. The child's attention, therefore, is unhampered in this particular, and is fully given to the movements.

In this connection, it may be remarked that the size of the crayon that is put into the child's hand at this stage makes no perceptible difference as to ease of coördination, provided the diameter of the marking instrument is not less than $\frac{3}{8}$ of an inch. A series of tests and observations was made by the writer, using lead-pencils and pens and holders, in which the size of the penholder was increased to $\frac{5}{8}$ in. in diameter. Some relief was afforded the child by this, but it did not lessen those clutching and strained movements well known to every teacher. This experiment served a most useful purpose in revealing the fact that the friction of the pen or pencil on the paper is a factor that may be remedied.

Employment for the left hand — Having set forth the proper instrument for the beginner to use in writing at the desk, and having shown the necessity that some employment be given to the left hand in writing, there arises the question of devising some means that will give the left hand this active employment. It will be found that it is not enough to ask the child to hold the paper firmly on the desk with the left hand. Such use is not sufficient, for the left hand will in a brief time

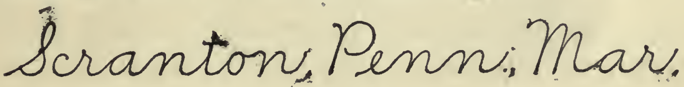
be drawn down on the paper nearer the child's side; shortly, the arm and elbow will drop below the desk, and the child fall into that objectionable posture which has already been referred to. The device of using strips of paper 5 or 6 in. wide and 3 or 4 ft. long will remedy this. It may be remarked that the kind of paper for this use is printing paper of the cheapest grade, with no gloss and a slightly rough surface. As the pupil writes a word let him move the paper along, thus keeping the writing directly in front of him and neither to the right nor to the left. By this means, the active employment of the left hand will be found sufficient to obviate the dropping of the head and the bending of the spine to the left and the drawing of the left arm down below the desk and nearer the side.

It will be found advisable and profitable to continue this plan for a year. Then the pupil can be given a pencil, but with wax filling instead of graphite. Blaisdell's pencils are excellent, because by unwinding the paper the child can sharpen his own pencil. Instead of strips of paper, a sheet of paper of the same quality as that used for the long strips may be given him, but rather large, $8\frac{1}{2} \times 10$ in. After the use of this for a term, or better a year, he is ready to employ the pen, but the pen which he first uses should be a very coarse one.

Freedom and ease of movement the aim — The aim from first to last in the teaching of writing should be freedom and ease of movement. The coördination of

muscles must not be hastened, but allowed to come naturally. Nicety and exactness of form are not to be held up as an ideal. These, while necessary, must be secondary to equilibrium and ease of movement, which should be gradually guided into ease in precision of movement. The movement, it should be said, must be one of the whole arm from the start till the child reaches the seventh school year. No finger movement must be permitted. When the child has acquired with the arm ease and precision in the writing of sentences, all requisite finger manipulations of the pen will come naturally and unconsciously. The pupil must not be urged to acquire speed, until he has acquired ease and precision in the movements of the arm. This is usually not attained much before the seventh school year. For the sixth school year a speed of eight to ten words, of five letters each, a minute is all that should be required. By the end of the seventh school year, a speed of from twelve to fifteen words a minute is all that should be expected.

Recent recommendation of intermedial slant—Recently there has been a rejection of the vertical hand on the part of some systems of schools, and an adoption of what is termed the intermedial slant. This is simply a new name for the slant of 75° which was advocated for a long time in Great Britain and the Colonies by the late Vere Foster. This slant is here shown.



As a compromise, it is, of course, to be acknowledged that this is a decided gain over the much more injurious slant of 52°, the Spencerian slant, which prevailed almost universally in this country up to 1892. The reasons adduced for the change to the intermedial slant were that in the use of the vertical script there seemed to be a small tendency to backhand, the writing was said to be slower, and it was reported that there existed an objection on the part of business men to the vertical hand.

In regard to the recommendation of change from the vertical to the intermedial slant, it is to be said that the results and conclusions in favor of vertical writing reached by able investigators, many of whom were physicians, cannot be so easily set aside. Conclusions reached after long and thorough investigations cannot be disregarded or turned down without a thorough and systematic presentation of new facts discovered which would modify the previous conclusions. Empirical judgment as to the failure of the vertical script, where conditions have been most unfavorable, where not one per cent of the desks at which the pupils wrote were adjustable even as to height alone, not to mention minus distance and the proper slope, and where a full knowledge of the hygienic principles involved in vertical writing was not disseminated, cannot be accepted as of scientific value.

CHAPTER XI

Conditions conducive to Healthful Mental Work

Fatigue — In 1879 Sikorsky published the results of a series of experiments to determine the effects of mental work throughout the five hours of the school day, upon the child's mental power. The results of the next investigation, made with the same end in view, were published by Burgerstein in 1891. Since that time more than a dozen investigators in Europe and America have worked upon the problem of fatigue. After reading these investigations, one questions whether such a complex matter as mental fatigue, indubitably involving many factors in varied relations, can be measured or determined by the methods employed in these studies. And it may be said that the investigations have brought out very little, if any, new guiding knowledge. While, however, they have added very little, if any, new knowledge to guide teachers, they have nevertheless served a useful end in drawing attention to the danger of overpressure from school work, and accordingly they serve to put teachers on their guard in this particular. They serve, moreover, to emphasize

a fact well known in medicine, namely, that when mental application on the part of the pupil is carried beyond a certain limit, not only is more lost under such conditions than is gained in developing the mental powers, but also the nervous mechanism receives impairment from which it must recover before the pupil is able to put forth again normal and healthful application. And further, if the over-mental application on the part of the pupil goes on day after day, permanent injury results to the nervous mechanism, which may reveal itself in several ways: in a difficulty which the mind experiences in applying itself to the gaining of knowledge, in an inability to retain clearly a series of ideas or to acquire more complicated forms of mental activity, or in some other pathological condition.

It should be remembered that the effort which a pupil must put forth in order to acquire new ideas and to organize them, in other words, to elaborate present processes of thought into more complex processes, uses up mental energy much more rapidly than teachers and instructors are likely to realize.

Minds, moreover, differ greatly in the amount of energy which they are capable of putting forth to acquire the different kinds of knowledge. There are also individual differences in the same person. One study may prove easy of acquirement, while another study will prove difficult. Furthermore, overpressure frequently comes, not so much from the fact that the

pupil is inherently incapable of making satisfactory advancement in a subject, as from the fact that he is put at the subject too early, or in other words, before his powers are sufficiently developed to enter upon a profitable pursuit of the subject.

It must also be said that some teachers cannot present subjects as clearly as other teachers, and that under teachers whose presentation is lacking in directness, clearness, etc., pupils must put forth a greater amount of effort, and accordingly use up a greater amount of energy. Taking into consideration these facts, individual promotion according to the capacities which pupils show is one means of obviating overpressure. There are several plans of such promotion in operation, and excellent results have been achieved by the individual promotion of pupils. The most carefully developed plans are those in Cambridge, Mass.; Keene, N. H.; Woburn, Leominster and Middleboro, Mass.; Le Mars, Iowa; and the North Side schools of Denver.

The plan of electives pursued in the high school of Galesburg, Ill., should be mentioned in this connection. The largely increased attendance, as well as the greater number of students who pass well in certain subjects that before the adoption of the elective systems caused many failures, are significant in their bearing upon overpressure, individual capability, and readiness.

The daily programme — The daily school programme may be so arranged as to become a factor contributing to

fatigue. In order to obviate fatigue, the daily programme should be arranged so as to engage successively different kinds of mental activity on the part of the pupil; in other words, one kind of mental activity should not be unduly continued. A proper arrangement brings a variety of exercises, and through variety relief for any one set of mental powers is afforded. The most taxing work should come when the children are freshest, which is during the first hour in the day. Pupils think better, their memory is better, their reaction time shorter at this hour. The practice, therefore, which has grown out of the experience of teachers for a long time, of putting mathematics the first thing in the morning, is a safe one, for the computations which mathematics involves are tiresome and monotonous, and the associations to be formed in the study of this subject, because of their abstract nature, are taxing in a high degree upon the mind.

Apart from mathematics, it cannot be said in just what order studies should come. This must be left to the observation and judgment of the teacher. We know, however, apart from the pedagogical investigations upon fatigue, that subjects requiring little mental effort should come in the afternoon, for Donaldson states that there is a tendency to run down toward the middle of the afternoon, with a return of vigor later in the day.

Gymnastics cannot be regarded as altogether rest.

They require brain work. They give rest in a certain way, but not complete rest. They should not take place after fatigue from brain work, nor be given after three hours of close study and recitation.

Other points that should be borne in mind, not only in the arrangement of the daily programme, but in carrying it out, are that inactivity on the part of the child from sitting in his seat too long is a factor productive of fatigue. There should, therefore, be as much change from sitting as possible. Again, there should be as much rest from severe strain upon the eyes as possible, as eye strain is unquestionably a prominent cause of fatigue. The work should be arranged to avoid protracted reading, and the teacher should be especially careful in regard to the strain put upon the eyes on dark days.

A recess in the middle of the morning and of the afternoon session unquestionably relieves the pupil from mental effort. Bringing into vigorous activity physical powers and with these, mental powers not called into activity in the schoolroom, it must therefore ever be regarded as a wise preventive of some of the effects of fatigue.

The length of the periods given to recitation in the various school years is an important matter. It will be found that much more can be gained by short, intensive periods of recitation, followed by activity of a different nature, than can be gained by long periods

of recitation. The mistake is constantly being made in the arrangement of school programmes of requiring pupils to give attention for too long a period. A safe guide as to the length of recitations for the different school years is as follows: for the first year the recitation in any subject ought not to exceed 10 minutes; for the second year, it ought not to exceed 15 minutes, but should oftener be but 10 minutes in length; for the third year, 15 minutes; the fourth year, 20 minutes; the fifth year, 20 minutes; the sixth year, 25 minutes; the seventh, 25 minutes, to possibly, under some conditions, 30 minutes; for the eighth year, 30 minutes; in the first year of the high school, it ought not to exceed 40 minutes; and for any of the higher years in the high school, it ought not to exceed 45 minutes.

Long sessions — One continuous session lasting till half-past one or two o'clock, as in many high schools, even though there is a short recess, is unquestionably detrimental to mental and physical health. The objections are that pupils go too long a time without food, or with a slight and insufficient lunch. With so long a session, pupils do not reach home until half an hour or more after the time of dismissal. By the time the midday meal is eaten it is about mid-afternoon. This, on hygienic grounds, is extremely bad. Too often the breakfast eaten is a slight one. The exactions of the morning recitation and study are severe. The continual mental exertion and tension of the morning leave

pupils in a condition not favorable to digestion. The period from breakfast to lunch or dinner, as the case may be, is a long one, and the pupil is likely to eat too much, and is not in a condition to digest a heavy meal. If high schools must hold one continuous session, then time should be given for a proper lunch some time during the morning, and some supervision should be instituted by school authorities to see that the ill effects upon health of improper food taken at these lunches may be avoided.

Some schools provide a counter at which pupils may purchase a mid-morning lunch; but the kinds of food offered, and the selections which boys, and more especially girls, make are pernicious to digestion and health. When such counters are established, the articles of diet offered should be limited to simple and nutritious kinds, with milk and bouillon.

The noon intermission, where schools have a full morning and afternoon session, should be of greater duration than an hour. A school may safely run up to twelve o'clock, provided there is afterward a noon intermission of an hour and a half.

Hours of study out of school — Little study should be required of pupils in the elementary grades outside of school — none whatever before the seventh school year, and not to exceed three-fourths of an hour daily for that year; for the eighth school year, not to exceed one hour. If parents ask that their children be given

some task for occupation at home to aid in establishing habits of industry and self-reliance, home work involving activities of construction, the use of the hand in conjunction with the eye, may be assigned. Constructive work of manual character will fully answer such a purpose. It is concrete and engages the child's interests. It is educative in the highest degree for the child at this period, and is of immeasurably greater value to him in all that makes for true mental development than sitting down at his table and acquiring lessons from books.

Examinations — There is great danger of over mental exertion during examination week. An examination in the upper grades of the elementary school should not last more than an hour and a half, and in the high school it ought not to exceed two hours. Some States and many high schools bring two examinations on the same day, one in the morning and one in the afternoon. When the strain under which pupils are placed who undergo examinations is considered, when the long preparation, sometimes until late the evening before, and sometimes studying before coming to school, is borne in mind, it must be apparent without any argument that the strain put upon pupils by a week of examinations is very great. It ought not, therefore, to be compounded by setting two examinations on the same day.

CHAPTER XII

Diseases which concern the School

The remarkable advances in medical science during recent years have brought to common knowledge the nature of certain dangerous diseases and their propagation. Vital statistics plainly show that wherever the measures recommended for the prevention of such diseases are observed, the spread of those diseases is largely checked and mortality surprisingly reduced. The school, because it assembles children from different homes and brings them into close contact, becomes under certain conditions a medium for the spread of infectious and contagious diseases. The newer knowledge of the specific cause and propagation of such diseases imposes a new duty upon school authorities, making it incumbent upon them to exercise every care and precaution lest the school become an agent in spreading disease. Regard for individual rights requires that no child shall be exposed in school to contagion or infection, if by taking certain precautionary measures such exposure may be avoided.

The establishment of medical inspection of schools would bring about satisfactory conditions, as in each

case the matter would be in the hands of a carefully trained physician, whose authority in the exercise of measures which he deemed wise and necessary under any emergency that might arise would not be questioned. But medical inspection of schools, though now instituted in some systems, is a matter, so far as its general adoption is concerned, of the future. Wherever, then, medical inspection of schools does not exist, the teacher must be relied upon to detect any symptoms which may be suspected to be those of communicable diseases, and to exercise promptly such measures as will prevent exposure of the other children of the school. When doing this, there will unquestionably occur instances in which alarm will later prove to have been unfounded. Nevertheless, the teacher, through the measures taken, places the entire school on the safe side. It is inconceivably better, therefore, that every now and then a suspected case should prove to be unfounded, than that a single child in a condition to communicate infection should be allowed to remain at school, and as a result the disease be spread in several homes.

We shall enter here upon a brief description of diseases which concern the school. Some of these are communicable, others are not. We shall describe as best we may the symptoms which accompany the advent of the disease, and shall suggest what school authorities and the teacher should do in cases of com-

municable diseases, and also what may be done to ameliorate the effects of the other diseases to be mentioned. A description of the various symptoms can be given only in a general way. Of course it is apparent that no exact descriptions can be given which will prove an infallible guide. In some cases a physician would be in doubt, and would be unable to decide until the symptoms became more pronounced.

Diphtheria — Diphtheria ranks first among the diseases which we shall mention, as to mortality. Since 1891 the cause of diphtheria has been known to be a bacillus. The bacillus was described by Klebs in 1883, and isolated by Loeffler in 1884. The bacilli of diphtheria generally gain a lodgment on the mucous membrane of the throat or nose from air that is breathed, or by direct contact from pencils, slates, drinking cups, or some other article upon which they have been deposited. As soon as the bacillus is lodged, it grows rapidly, forming what is termed the diphtheritic membrane on the mucous membrane of the tonsils, larynx, or nose. The disease is spread by bacilli or germs coming from the excretions from the throat, mouth, or nose of those affected with the disease. Everything which comes in contact with the mouth, or upon which discharges of the mouth, throat, or nose find a lodgment, may therefore spread the disease. The bacilli of diphtheria are capable of producing infection for a long period after their discharge

from a person having the disease. They have been found to be virulent after seven months. The disease, then, may be spread from the dust of the excretions which have fallen upon clothing, upon books, carpets, or walls, and the bacilli may even adhere to particles of ordinary dust. It will, therefore, be seen how essential the most thorough disinfection is, and how stringently it must be insisted upon by school authorities before a child who has had diphtheria can be readmitted to school.

The symptoms which must guide the teacher in suspected cases are sore throat, which may or may not be accompanied by a chill, irritability, and nervousness showing itself in a trembling of the hand in writing. There is usually not much fever, from 101° to 102°.

Should it prove that the child has diphtheria, all pupils from the same household should be excluded from school, and should not be allowed to return to school except upon the statement of a physician that it is safe for them to do so, and that their return will not endanger others. As the diphtheria bacillus has been found in the throat several weeks subsequent to seeming recovery from the disease, it will be seen that a safe period of time must be imposed before readmission to school. Because of the duration of infectiousness, three weeks is the shortest time, in severe cases, after the membrane has disappeared, in

which a pupil is to be readmitted to school, unless culture tests made in the laboratory show that there is entire absence from the throat of the bacilli. In mild cases the quarantine should be imposed for ten days. In either case, school authorities would be on the safe side in requiring, before the readmission of the child, a medical certificate stating that a laboratory culture shows the throat to be free from bacilli.

Scarlet fever — Scarlet fever is one of the most contagious diseases, and the school, even though the greatest care is exercised, may become an agent in the insidious spread of this disease. It is not yet known what the nature of the contagium of scarlet fever is, but analogy suggests that it is due to a micro-organism. It is spread by inhaling the contagium. The disease is communicated by the scales which peel from the skin during recovery, by discharges from the mucous membrane, which is especially "involved" in the course of the disease. It is also highly probable that scarlet fever is communicated by all excretions, even including the perspiration of the patient. The germs of the disease may be taken in from bed-clothing, carpets, curtains, and the furniture of the sick-room, from books, and from the clothing and shoes of the patient. Instances are on record where the disease has been spread by food, especially milk, and by domestic animals. Scarlet fever may be spread from the beginning of the

appearance of the first symptoms, even before the appearance of the rash. What makes scarlet fever a disease so much to be dreaded is, first, the insidious manner in which it is propagated; second, the fact that mild cases are as contagious as severe cases; third, that the contagium from a mild case may result in a severe attack of the disease; and lastly, that children may have scarlet fever in a mild form and be at school, and the disease not be detected, because the peeling may be so slight as not to be recognized.

The germs of scarlet fever, if disinfection has been neglected, may remain in clothing, especially woollen, and communicate the disease for an indefinite period afterward.

The invasion of the disease manifests itself usually by vomiting, a sore throat, and an increase of temperature. Later the rash appears, showing itself first upon the neck. In mild cases the symptoms are not so evident. The temperature may be from 100° to 103°. The appearance of any of these symptoms in a child would warrant the teacher in sending the child immediately home, and notifying the proper authorities.

School authorities are thoroughly justified in establishing the most rigid quarantine upon children who have had scarlet fever, as well as upon children from households where a case has occurred. At least six

weeks should elapse from the first symptoms of the disease before the child is readmitted to school, and even then before the child is allowed to return to school a certificate should be required from the physician to the effect that the scaling is thoroughly over, and stating in addition to this that the child is suffering from none of those complaints which follow scarlet fever, as the fever may be spread from some of the diseased conditions resulting from the attack. Children of a household in which a case of scarlet fever has been reported should be excluded from the schools during the period of the active progress of the disease. The length of time which such children should be quarantined is on the average one month. It becomes necessary to make this stringent requirement lest such children might themselves have the disease in so mild a form as not to be recognized. This stringent rule is warranted for another reason, namely, that in many homes the complete isolation of the patient, as well as the rigid precautions to be observed against the communication of the disease, cannot be carried out in nursing a patient, and therefore the other children of the family are likely to bear the contagium on their clothing, and thus be carriers of the disease.

Epidemics of scarlet fever are most frequent in the fall and winter, occurring less seldom in the summer. During periods of an epidemic of scarlet fever, as well as of diphtheria, the schools should be closed.

If a child has been exposed to the contagium of scarlet fever and a week passes without there being any symptoms, the probabilities of infection are very small.

Measles — Measles is a very contagious disease. Its exact cause has not yet been ascertained. Analogy would suggest that it is due to a micro-organism, but up to the present time all efforts made to isolate the suspected germ have proved futile. The contagium of measles is spread with great rapidity from a person sick with it, before the eruption appears. The disease is communicated on very short exposure, and nearness to a patient is not necessary. The contagium of measles is unlike that of scarlet fever in that it does not persist for a long period. The disease is rarely spread by clothing, or by the furniture and walls of the sick-room.

The disease may make its appearance after exposure in from seven to twenty-one days. The symptoms which characterize the beginning of an attack of measles are sneezing and a discharge from the nose, eyes becoming red and sometimes running, together with sensitiveness to light. There is frequently a hoarse, hard cough and soreness of the throat. Sometimes the attack, especially when epidemics prevail, is accompanied with high fever. Headache, a feeling of dulness, and pains in the back are not in themselves to be regarded as symptoms of measles, for these accompany the invasion of many diseases.

Measles is generally regarded by the public as a disease which among school children results in little mortality, and also as a disease which nearly every person contracts at some period of life, the first attack giving immunity, as a rule, from any further attack. School authorities, therefore, are likely not to take adequate measures to prevent the spread of this disease. While it is true that in children of school age an attack of measles is usually mild, it is not so with infants, with children of delicate constitutions, or with children in which there is a predisposition to pulmonary disease of any kind. Efforts, therefore, should be made to restrict the spread of measles to the utmost, in order to protect infants and those children in whom the disease entails evil results. A child showing any of the symptoms spoken of should be immediately sent from school and kept from school at least four weeks. The children of the same household should not be permitted to attend school while any members of the family are sick with the disease, as owing to the rapid spread of this disease from patient to patient, the invasion of the disease may occur at school, and the disease be spread to a great number of pupils.

A medical certificate in the case of measles does not seem necessary when the child returns to school, provided he has been excluded from school the proper time.

Epidemics of measles occur with greatest frequency

and severity during the spring months, and occur with least frequency and are mildest in the autumn months.

Whooping-cough — Whooping-cough is a disease that is rarely attended with fatal results or serious consequences with children of school age, but because of its mortality during the period of infancy, especially in the first year, it is a disease greatly to be dreaded. Two-thirds of the deaths resulting from whooping-cough are of children in the first year of infancy. The cause of the disease has not yet been ascertained. It is thought, however, to be due to some micro-organism. The disease is spread by proximity to a child having it, and close proximity is not necessary. The disease may be communicated from the very beginning of its invasion, which is called the catarrhal stage. It is not definitely known how long a given case may communicate the disease. It is pretty well established, however, that the disease may be communicated throughout the spasmodic stage. The symptoms at the beginning of this disease are not such that they are recognizable from an ordinary cough. In some cases the child will whoop from the beginning of the disease. In other cases the child will have a paroxysmal cough for several weeks before any pronounced whoop is noticed.

For the reasons already stated with reference to its fatal results in infancy, the disease is one which endangers public health. Therefore a child with whooping-cough should not be allowed to attend school. The

quarantine should be enforced for two months from the beginning of the attack.

Mumps — Mumps is one of the contagious diseases. It is characterized principally by a swelling of the parotid glands. The disease is spread by close contact, but it is much less contagious than any of the diseases thus far mentioned. Children are not greatly susceptible to the contagium of this disease. Statistics show that only a small number of those exposed to the disease contract it. The disease may be communicated for several days after the swelling has subsided. As mumps is a mild disease, there is little danger to be feared from it, except in the case of boys during adolescence. A child having the disease should not be allowed at school, and should be quarantined for three weeks from the beginning of the disease, or for ten days after the disappearance of the swelling. It will be safe to exclude a child who has contracted mumps from school for three weeks.

Varicella; Chicken pox — It is not necessary to say anything upon this communicable disease, which is usually a mild one, except that a child having it should be excluded from the school for three weeks after the appearance of the first symptoms.

The habit of spitting — From the descriptions which have been given of communicable diseases, it will be seen how potent a factor in their spread are discharges from the throat and nose. The mucus so discharged

dries, with the result that the germs it contains are carried about by the air. It is now well established that saliva itself contains many species of micro-organisms. They are brought to the mouth by breathing air which contains them, and in other ways as well. They are arrested by the moisture of the mouth and are then gathered quickly in the saliva. The sputa of persons having consumption contain the germs of this disease, and it is now thoroughly established that consumption is spread by air containing the germs disseminated from the dried sputa of those suffering from this disease. It will be seen, therefore, that the habit of spitting is a great contributory factor in the spread of certain infectious diseases. Through an enlarging public appreciation of its dangers, concerted efforts are now being made to restrict and also to prohibit the practice of spitting in public buildings and in the streets. The school should enlist itself in such an important movement as this. While it is true that in all well-conducted schools such a practice as spitting on the floor is not tolerated, and while it is true that the use of saliva on slates is not permitted, yet the school must do more than this. It can achieve very lasting results, and at the same time greatly extend a knowledge of the dangers ensuing from the practice of spitting, by enlisting the pupils' interest in the matter through instructions accompanied by pictures of the bacilli, projected by a lantern upon a screen. In every school, at some time during the year,

all the grades might be assembled and instruction of this kind given. Such instruction would not only extend to the home and the public, but it would also prove of incalculable influence in leading pupils to form the habit of never expectorating and also in inducing them to keep up that habit after leaving school.

Contagious conjunctivitis — This affection of the lining membrane of the eyelids and of the periphery of the eyeball is commonly known as "pink-eye." It is the most frequent contagious disease of the eyes incident to school life. Its cause is a micro-organism of the pus-forming variety. The disease is conveyed by anything which comes in contact with the discharge. The hands, handkerchief, clothing, washcloths, sponges, and towels are the usual means of communicating the germs. During some recent outbreaks of the disease the epidemic was spread by means of the bath water in public bathing houses. Filthy water may itself contain the germs and thus communicate the disease to those who bathe in it. When the disease appears in one member of the school it is altogether likely to become epidemic.

The signs of the affection are redness of the eyeball and lining of the eyelids, a discharge from the eyes, at first watery, but later becoming mucous, and finally yellow and sticky from the amount of mucus and pus present. The eyelids are apt to be glued together in the morning. Sensitiveness to light is another symptom.

Unless energetic treatment is undertaken when the disease makes its appearance, it is likely to persist for a long time, and serious damage to the delicate structure of the eye may result. A pupil, therefore, having the disease, must be immediately excluded from the school and be kept away until pronounced entirely well by a physician. The necessary further precaution against the spread of the disease in school is the thorough cleansing, with some antiseptic solution, of the balustrades, the desks and seats of the affected pupils, the doorknobs, and the parts of the doors which come in contact with pupils' hands.

Chorea — Chorea is a nervous disease of a functional nature, and is characterized by peculiar and unusual contractile movements of voluntary muscles. This disease is most frequently found in children from seven to fourteen years of age. More than twice as many girls are subjects of the disease as boys. The disease occurs much oftener in the spring months than in any others, though it may be met with at all seasons of the year. The disease is usually very gradual in its approach, and the first symptoms are those of nervousness. The child shows a lack of power over certain muscles, which manifests itself in a difficulty on his part to write or to command his hands in such fine movements as he has been wont to execute, and also in dropping things. A delicate twitching of the hands may often be detected by the teacher, if he holds the pupil's hands

lightly in his own, before the twitching is evident to the eye. Sometimes the disease first affects the legs. Stumbling characterizes the child's walking, and he finds difficulty in going upstairs. In some cases the disease first shows itself in twitchings of the muscles of the face or of the eye, associated with a difficulty of articulation. The symptoms of this disease are so characteristic, and are so unlike any other movements of the child, that they cannot be mistaken. A fright is frequently an exciting cause of chorea, especially when tendencies and previous conditions have rendered the child predisposed to this disease. An anæmic condition of the system in the greater number of instances is a predisposing factor. Worry over lessons, too severe study coupled with continued sleeplessness, nervous anxiety on the approach of examinations, and even punishment at school, if the child deems it unfair, are important factors in bringing on an attack of chorea.

A child afflicted with chorea should, of course, for his own welfare, be immediately removed from the school, as recovery from the disease under proper treatment and care is usually a matter of only a few weeks. If circumstances are such that the child is not removed from school, the teacher must deal with the child with extreme care. No demands should be made by the teacher upon him. Work may be assigned as it is to the other members of the class,

simply that the child may be recognized as are the other pupils in the class. He should be left, however, to accomplish what he may, and no adverse comment or corrections of errors and mistakes should be made, as this would tend to disconcert the child and aggravate his nervous disorder. As the disease in those predisposed sometimes arises from imitation, the child should be given a seat in that part of the grade or class where its facial twitchings or spasmodic movements will be noticed as little as possible by the other pupils. The teacher should also protect the child at recess and dismissal, so that he may not be annoyed or teased by the inconsiderate and irresponsible members of the class.

Adenoid growths — In the vault of the pharynx there is a spongy tissue which resembles somewhat the tissue of the tonsils in its structure. It is a very common occurrence for this tissue to grow excessively and become so large as to exert considerable pressure in the region occupied by it in its natural conditions. Such growths are adenoids. On account of this growth the child feels constantly a pressure in the head, he is unable to breathe freely through the nose, and his hearing is frequently affected. He cannot, therefore, give the attention that is expected of him to lessons and school exercises. Memory seems to be defective in such cases. For these reasons, the pupil affected is usually pronounced dull. The char-

acteristics by which the teacher may judge whether a pupil has adenoid growths are a stubborn nasal catarrh accompanied by mouth breathing and slight deafness. The voice has a "nasal" quality. The child experiences much difficulty in blowing the nose; frequently he is entirely unable to do so. The expression of the face in adenoid growth is stupid and dull. Children with adenoid growths are more liable to contract tonsillitis and diphtheria than other children, and attacks of these diseases, as well as of scarlet fever, measles, and whooping-cough, are likely to be much severer in type than with other children. If it is possible the adenoid growths should be removed. On their removal there is noticeable a very great improvement mentally in the patient. The child's memory is much improved. He gives attention easily, and his progress at school is noticeably greater.

Pediculosis — The most frequent parasitic disease is due to one of the varieties of the common louse. Head lice are more likely to be found among unclean and poorly nourished children. Their presence may produce, through irritation, impetigo. This is contagious and sometimes spreads among children.

The signs leading one to suspect the presence of head lice are scratch-marks on the forehead or behind the ears. These scratch-marks may be accompanied by the enlargement of the small lymph kernels at

the back of head. Careful inspection of the scalp or of the hat or hood in a good light may reveal the parasite itself — a gray-backed creeping insect, about one-twelfth of an inch in length. More frequently, however, the parasite is not found, but the eggs or "nits" may be discovered on the hairs, about a half an inch from the roots. The "nits" are little glistening oval bodies, about one-twentieth of an inch in length. They are drab in color and are attached to the hair with their smaller end directed toward the scalp.

A pupil whose head is infested with these parasites should be excluded from school and not readmitted until careful examination of the scalp and hair shows no sign of the parasite.

The head may be rid of the parasites and "nits" by wrapping the head for two successive nights in cloth wet with either tincture of larkspur or kerosene. The head should be thoroughly washed each morning after the application, with castile soap and water. The cap, hat, or hood should be thoroughly cleansed with kerosene or the tincture, and, if feasible, afterward washed in soap and water. As tincture of larkspur is poisonous, care must be taken to keep it away from the mouth.

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